EAST MOUNTAIN
CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT
(CHIA)

For

COTTONWOOD/WILBERG MINE
C/015/0019

DEER CREEK MINE
C/015/0018

DES-BEE-DOVE MINE
C/015/0017

CRANDALL CANYON MINE
C/015/0032

In

EMERY COUNTY, UTAH

March 28, 2005

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I INTRODUCTION

East Mountain and the East Mountain Cumulative Impact Area (CIA) are located in Emery County, Utah, west of the town of Huntington (Plate 1). There are currently two active mines in the East Mountain CIA - PacifiCorp's Deer Creek Mine and the Crandall Canyon Mine, jointly owned by Andalex Resources, Inc. and Intermountain Power Agency (IPA). PacifiCorp has two inactive permitted operations in the East Mountain CIA - the Cottonwood-Wilberg Mines and the Des-Bee-Dove Mines: Phase I reclamation (demolition of structures, backfilling and grading, and seeding) at the Des-Bee-Dove Mines was completed in June 2003. (PacifiCorp's inactive Trail Mountain Mine, located immediately west of East Mountain and separated from it by Cottonwood Creek, is outside the East Mountain CIA.) Mountain Coal Company's Huntington #4 Mine was reclaimed in 1985 and released from reclamation bond in 1998.

Expansion of the Deer Creek Mine into the Mill Fork, Joes Valley, and Crandall Canyon drainages required an update of the Cumulative Hydrologic Impact Assessment (CHIA) in March 2003. Leasing of the coal in the South Crandall Canyon Coal Lease Tract (UTU-78953) in June 2003, the addition of several adjacent coal tracts in 2004, and PacifiCorp's proposed access and fan portals in Rilda Canyon triggered this review and update of the East Mountain CHIA.

The Division has the responsibility to assess the potential for mining impacts both inside and outside permit areas. The CHIA is a findings document prepared by the Division that assesses whether existing, proposed, and anticipated coal mining and reclamation operations have been designed to prevent material damage to the hydrologic balance outside the permit areas. The Division cannot issue a permit to a proposed coal mining operation if the probable, anticipated hydrologic impacts will create material damage to the hydrologic balance outside the permit area. The CHIA is not only a determination if coal mining operations are designed to prevent material damage beyond their respective permit boundaries when considered individually, but also if there will be material damage resulting from effects that may be acceptable when each operation is considered individually but are unacceptable when the cumulative impact is assessed.

The objective of a CHIA document is to:

1.	Identify the Cumulative Impact Area (CIA)	**(Part II)**
2.	Describe baseline conditions in the CIA; identify hydrologic systems, resources and uses; and document baseline conditions of surface and ground water quality and quantity	**(Part III)**
3.	Identify hydrologic concerns	**(Part IV)**
4.	Identify relevant standards against which predicted impacts can be compared	**(Part V)**
5.	Estimate probable future impacts of mining activity with respect to the parameters identified in 4	**(Part VI)**
6.	Assess probable material damage	**(Part VII)**
7.	Make a statement of findings	**(Part VIII)**

This CHIA complies with the federal Surface Mining Control and Reclamation Act of 1977 (SMCRA) and subsequent federal regulatory programs under 30 CFR 784.14(f), and with Utah regulatory programs established under Utah Code Annotated 40-10-et seq. and the attendant State Program rules under R645-301-729.

II. CUMULATIVE IMPACT AREA (CIA)

Reviewing Permit Application Packages (PAP) and Mining and Reclamation Plans (MRP) alone is not sufficient to assess impacts to the geologic and hydrologic regimes. Specific knowledge of the geology and hydrology is crucial in assessing the dynamics and interactions of chemistry, surface- and ground-water movement, and associated subsidence impacts to a minesite. The Division uses pertinent information from many sources, including federal and state agencies; geological and hydrological reports; textbooks and other publications; site visits; and a knowledge base built on experience and training.

Plate 2 delineates the CIA for current and projected mining in the East Mountain area. The CIA encompasses approximately 109 miles^2 centered around East Mountain: the area within the CIA that is above the base of the Blackhawk Formation is approximately 69 miles^2, and the approximate area covered by coal leases is 52 miles^2. Mine workings have or will undermine roughly half of the leased areas. Huntington Canyon, Scad Valley, Joes Valley, and Cottonwood Canyon are the primary features bounding the CIA.

SCOPE OF MINING

Coal has been mined from East Mountain since the late 19th century. The old, typically small mines on East Mountain - such as the Rominger (Ferrell), Jeppson, Leroy (Comfort), Johnson, and Helco Mines - are not discussed in detail. Many of the disturbed areas associated with these old mines have been incorporated into larger, more recent mines permitted under the Utah coal mine regulatory program. The Division's AML program has done reclamation at some of the old mines.

PacifiCorp Mines

The Cottonwood/Wilberg and Deer Creek permit areas overlap, and the Des-Bee-Dove permit area is immediately adjacent to them. Together, the three permit areas encompass approximately 29,000 acres. Utah Power and Light (UP&L), which was merged into PacifiCorp in 1989, acquired these mines from earlier operators. The mines are now permitted to PacifiCorp, a subsidiary of Scottish Power, and since 1990 the mines have been operated by Energy West Mining Company, a wholly owned subsidiary of PacifiCorp.

Cottonwood/Wilberg Mine

The Cottonwood/Wilberg Mine permit area presently covers approximately 11,500 acres, a combination of fee lands and federal and state leases: some coal leases have been relinquished by PacifiCorp but the permit still includes those areas. Coal has been produced from the Hiawatha Seam, using both longwall and continuous methods.

Coal mining operations have existed in the Wilberg area since the 1890's. Cyrus Wilberg began operating the Wilberg Mine in 1945. UP&L acquired the Wilberg Mine in September 1977 from the Peabody Coal Company, which had acquired it in 1958. UP&L acquired a large, adjacent federal coal lease, called the South Lease, in 1982.

A tragic fire occurred in the Wilberg Mine in December 1984, and on July 1, 1985, the operation was divided into two separate and independent coal mines, the Cottonwood and the Wilberg Coal Mines. Each mine has a separate MSHA identification number; however, a single mining and reclamation permit (ACT/015/019) was issued to both mines because the surface facilities, on 20 acres at the head of Grimes Wash, are shared by both mines.

Mining resumed in the Wilberg Mine in September 1987 and the last coal was mined in January 1988. Longwall mining in the Cottonwood Mine ended in September 1995 and the equipment was moved to the Trail Mountain Mine. Total production to that time was 40 million tons, and remaining reserves in the Hiawatha Seam are estimated at 2 million tons. Portals for both mines are in the Hiawatha Seam, and only the Hiawatha Seam has been mined. There are Blind Canyon reserves, but there currently is no plan to recover these through the Cottonwood/Wilberg Mine.

After mining ceased in the Cottonwood/Wilberg Mine in 1995, a conveyor through the Cottonwood Mine continued to transport coal from the Trail Mountain Mine through East Mountain to the to the truck load-out at the Cottonwood Mine surface facilities in Grimes Wash. After operations ceased at the Trail Mountain Mine in 2001, the Cottonwood/Wilberg Mine was placed in temporary cessation.

Deer Creek Mine

Coal mining operations had taken place on fee land in Deer Creek Canyon prior to 1946, when the first federal coal lease was issued in this area. Peabody Coal Company acquired leases on the Deer Creek property and began operations in 1969. UP&L purchased the Deer Creek Mine in 1977 from Peabody. The current Deer Creek Mine permit area is approximately 24,600 acres, including approximately 5,560 acres added by the Mill Fork Extension.

The Deer Creek Mine surface facilities are located on a 25-acre site at the junction of Deer Creek and Elk Canyons, side canyons in the Huntington Creek drainage. The portals are in the Blind Canyon Seam. In the southern portion of the Deer Creek Mine, the underground workings are in the Blind Canyon Seam only: they overlap but are separate from the Cottonwood/Wilberg Mine workings in the Hiawatha Seam. In the Rilda Canyon area, rock slopes from the Blind Canyon Seam provide access to the Hiawatha Seam.

Entry to the Mill Fork Lease is by entries advanced from the Hiawatha Seam through

Lease Modification #3, a 65.7-acre area that has been added to Lease U-06039 for this purpose. Coal will be mined in both the Blind Canyon and Hiawatha Seams. The Blind Canyon is to be mined first, accessed from the Hiawatha through rock slopes that are to be built within the Mill Fork Lease area. Total cumulative vertical extraction from both seams will not exceed 20 feet. The full extraction methods to be used are anticipated to cause subsidence that can be planned and controlled.

Construction of new portals and a bathhouse in Rilda Canyon has been discussed with the Division, BLM, USFS, and DWR and plans have been submitted to the Division. The disturbed area will be approximately 12 acres, 3 acres being for topsoil and subsoil storage. The sedimentation pond will be on land previously disturbed by the Leroy (Comfort) Mine. These new portals will not be used for coal transport but will be used only for ventilation and transportation of workers and materials into the mine.

PacifiCorp may eventually add a ventilation breakout in Crandall Canyon, upstream of the existing Crandall Canyon Mine, but an application to add this breakout to the mine plan has not been submitted to the Division. The design of the breakout and the request for permit modification will be made based on the results of future coal exploration.

The majority of the Deer Creek Mine utilizes the longwall mining method. All underground operations, including the Mill Fork Extension, are projected to end around the year 2032.

Table 1
Annual Production in millions of tons
Deer Creek Mine

1997	4.5	(Utah Energy Office)
1998	3.7	(Utah Energy Office)
1999	3.8	(Utah Energy Office)
2000	4.2	(Utah Energy Office)
2001	4.3	(MSHA)
2002	4.0	(MSHA)
2003	3.9	(MSHA)
2004	3.4	(MSHA)

<u>Des-Bee-Dove Mines (Deseret, Beehive and Little Dove Mines)</u>

The Des-Bee-Dove Mines are located in an unnamed narrow, steep canyon that is part of the Grimes Wash drainage. Mining began in the canyon in 1898 as the Griffith Mine. From 1936 to 1938, mine workings were operated by the Castle Valley Fuel Company, owned by Messrs. Edwards and Broderick. The Church of Jesus Christ of Latter-day Saints (LDS Church) acquired 400 acres adjacent to the Castle Valley Fuel Company mine in 1938, and the adjoining properties were mined by both operators from 1938 to 1947. The LDS Church purchased Castle Valley Fuel Company in 1947, and Deseret Coal Company operated the mines for the church. UP&L acquired the Des-Bee-Dove Mine complex in 1972.

The Des-Bee-Dove Mine permit area, a combination of fee land and state and federal leases encompassing over 2,800 acres, contains two minable coal seams - the Hiawatha and Blind Canyon. The Dove and Beehive mines accessed the Blind Canyon Seam and the Deseret Mine the Hiawatha Seam. Mining was done by a series of continuous room and pillar sections. A series of north-south trending faults dictated mine layout. The mines were very dry, requiring importation of water to operate.

The three mines ceased operations on February 6, 1987 and the portals were sealed. Before operations ceased, the Des-Bee-Dove Mines were producing 725,000 tons per year. Reclamation of the entire Des-Bee-Dove site began in 1999 and Phase I reclamation (demolition of structures, backfilling and grading, and seeding) was completed in June 2003.

The Des-Bee-Dove paved coal-haul road was transferred to Emery County and removed from the permit, so the sedimentation pond and associated access road are now isolated from the rest of the permit area. PacifiCorp is currently revising the reclamation plan with the goal of removal and initial reclamation of the pond and pond-access road.

<u>Associated Sites</u>

Underground development waste, sediment from sedimentation ponds, and other coal mine waste from the Deer Creek, Des-Bee-Dove and Cottonwood/Wilberg Mines are stored at waste rock disposal areas located near the mines.

- Cottonwood/Wilberg - Des-Bee-Dove Waste Rock Disposal Site (inactive). BLM ROW U-37642 was issued in 1981. It is along the east side of state road 57. Of the original 49 acres, 14 acres were relinquished to Texaco for coal-bed methane operations, including a roadway that cuts through the middle of the site. South of the road, 14 acres have been reclaimed and 5 acres remain to be reclaimed, and 16 acres north of the road (including a vegetation reference area) remain undisturbed. Phase I Bond Release on the 14 reclaimed acres was granted on July 22, 1999 (ACT/015/019-BR98). There are no plans for further waste disposal at this site.

- Cottonwood/Wilberg –Trail Mountain - Des-Bee-Dove Waste Rock Disposal Site (inactive). BLM ROW-UTU-65027 was issued in 1990. This site is across state road 57 from the disposal site on ROW-U37642. Total area is approximately 26 acres, with 17 acres disturbed. Presently, waste is not being placed here because the mines are inactive.

- Deer Creek Mine Waste Rock Disposal Site (active). This site lies northeast of state road 31 on land owned by Utah Power & Light. The access road and waste disposal area cover approximately 32 acres.

The Cottonwood/Wilberg Mine sewer absorption field and sewer line, part of the permitted area, are located on BLM right-of-way U-37641 outside the main permit area boundary. This system is designed to also handle Trail Mountain Mine sewage, piped through the Cottonwood/Wilberg Mine.

There are several additional, small rights-of-way for power and telephone lines and haul roads.

Huntington Canyon #4 (Beaver Creek Coal Company)

The Huntington Canyon #4 Mine permit area contained 1,320 acres. The underground operations utilized room and pillar mining methods in the Blind Canyon and Hiawatha coal seams in Federal Lease No. U-33454 and SL-064903. All underground mine operations ceased November 1, 1984.

The mine working advanced generally to the northwest. The Blind Canyon Seam was mined within and northwest of the Mill Fork Graben. According to Dan Guy, former Engineering Manager for the mine (personal communication, February 26, 2003), the mine closed because of economic conditions related to coal quality: as mining moved northwest from the graben into what was called the Dellenbach Lease, the coal was oxidized and could not be economically processed.

The mine intercepted faults and some water sources, but Mr. Guy does not recollect large inflows to the mine. He speculated that the oxidation was the result of ancient activities and did not know if it was related to the recharge source to Little Bear Spring. Beaver Creek Coal Company commissioned a study by Vaughn Hansen and Associates (1977) that includedLittle Bear Spring; they concluded there was no connection between the mine and the spring.

Beaver Creek Coal Company reclaimed the #4 Mine site during the period of August 15, 1985 through September 30, 1985. Three portals and one opening were sealed. The disturbed area, including the access road, was backfilled and regraded. Soil was replaced and reseeded. The reclamation bond was released in May 1998.

Crandall Canyon Mines (Genwal Resources, Inc.)

Coal for local, domestic use was mined from Crandall Canyon from November 1939 to September 1955. Approximately 35,000 tons were mined from the Hiawatha Seam (Crandall Canyon Mine MRP, p. 4-6 and 4-7). There was no reclamation done.

Genwal Resources (Genwal) began mining in this area in 1983. Some of the older workings have been incorporated into the Crandall Canyon No. 1 Mine. Genwal and the mine were purchased by Andalex and Intermountain Power Agency (IPA) in 1995, but Genwal is still the operator. Both continuous and longwall mining methods are currently used. Pillars will be fully extracted unless they are needed for safety or to protect the outcrop.

Table 2
Annual Production in millions of tons
Crandall Canyon Mine

1997	2.7	(Utah Energy Office)
1998	3.5	(Utah Energy Office)
1999	3.8	(Utah Energy Office)
2000	3.9	(Utah Energy Office)
2001	4.0	(MSHA)
2002	3.3	(MSHA)
2003	1.2	(MSHA)
2004	1.0	(MSHA)

The permit area for the Crandall Canyon No. 1 Mine contains approximately 5,320 acres in Huntington Canyon in Emery County, Utah. Approximately 11 acres are disturbed. In February 1993, Genwal applied to lease 4,053 acres of Federal coal lands adjacent to the south of the Crandall Canyon No. 1 Mine, initiating the process that led to the leasing of the Mill Fork tract. However, PacifiCorp won the bid for that lease, which became the Mill Fork Extension of the Deer Creek Mine. In February 2005, Genwal received approval to begin mining an additional 120-acre Incidental Boundary Change (IBC) (addition to Lease U-68082) located at the northeast portion of the existing permit boundary.

<u>The South Crandall Canyon Coal Lease Tract - Lease U-78953</u>

The South Crandall Canyon Coal Lease Tract was deleted from the Mill Fork tract because of the concerns that were raised regarding Little Bear Spring. The South Crandall Canyon area was reevaluated, and based on a Decision Notice/Finding of No Significant Impact (DN/FONSI) signed by the BLM and USFS in February 2003, the South Crandall Canyon Tract was leased through competitive bid to Andalex in 2003.

The South Crandall Canyon tract covers 880 acres. There are an estimated 6 million tons of recoverable coal. Access is through new portals constructed in 2003 on the south side of Crandall Canyon, in fee coal that is jointly owned by IPA and Andalex but commonly referred to as the “Dellenbach“ lease.

A 40-acre parcel of the Mill Fork Lease has been transferred from PacifiCorp to Genwal to allow more efficient mine layout and increased coal recovery. A 160-acre fee tract has also been added, bringing total acreage to 1,080 acres in the South Crandall Canyon extension.

III. DEFINE BASELINE CONDITIONS; IDENTIFY HYDROLOGIC SYSTEMS AND USES, AND DOCUMENT BASELINE CONDITIONS OF SURFACE AND GROUND-WATER QUALITY AND QUANTITY

BASELINE CONDITIONS

East Mountain is located in Emery County, Utah, west of the town of Huntington and approximately 20 miles southwest of Price (Plate 1). It is in the Wasatch Plateau Coal Field. The eastern margin of the Wasatch Plateau is a rugged escarpment that overlooks Castle Valley and the San Rafael Swell to the east. Elevations along the entire eastern escarpment of the Wasatch Plateau range from approximately 6,500 to over 9,000 feet. The climate of the Wasatch Plateau has been classified as semiarid to subhumid. Precipitation varies from 40 inches at higher elevations to less than 10 inches at lower elevations, and ranges from 10 to 30 inches per year within the CIA (Danielson and others, 1981).

East Mountain is a north-south trending ridge, bounded by Huntington Canyon on the northeast and north, Left Fork of Huntington Canyon and Scad Valley on the north and northwest, Joes Valley and upper Cottonwood Canyon on the west, and lower Cottonwood Canyon on the south. The southeast side of the mountain is part of the Wasatch Plateau escarpment that separates the plateau from Castle Valley. Elevations in the East Mountain CIA range from 7,000 in the canyon bottoms to over 10,700 feet along the crest of East Mountain. Much of the surface is steep and dissected by steep, narrow canyons with heavy vegetation and barren cliffs.

Soils - based on information in the USFS 1997 Environmental Assessment (EA), pages III-3 and III-4

Shallow to very deep soils on the lease tract have developed primarily from sandstone and shale parent materials. Rock outcrops are common, especially within the Castlegate Formation. Because of the steepness of the slopes and rapid runoff, most soils are well drained.

Soils derived from sandstone are typically cobbly or stony with textures of loamy sand, sandy loam, or loam. Clay loam, silty clay loam, and clay are common in soils derived from North Horn Formation. Subsoils often have higher clay content than the surface.

Topsoil development is most pronounced under aspen vegetation types, where it is commonly 20 to 30 inches thick and has a relatively high organic matter and nutrient content.

On the steep, north facing slopes that support a spruce-fir type, topsoil thickness may vary from about three to ten inches. Alluvial soils are found in drainages.

The elevation range, steep slopes, and contrasting aspects account for large soil temperature and moisture differences. Soils on the lower-elevation south-facing slopes are hot and dry, and those at the higher elevations and on north-facing slopes are cool and moist. Soil temperature regimes include cryic (cold) and frigid, and the soil moisture regimes are udic (moist) and ustic (semiarid). The aspen and spruce-fir vegetation types are characteristic of the cryic/udic environment, and lower-elevation mountain brush with some pinyon-juniper is characteristic of the frigid/ustic situation.

Vegetation

Vegetation of the Wasatch Plateau area is classified within the Colorado Plateau floristic division (Cronquist and others, 1972). The area occupies parts of both the Utah Plateaus and the Canyonlands floristic sections. Vegetation communities of the area include desert shrub (shadscale) at the lowest elevations through sagebrush, sagebrush-grassland, pinyon-juniper, mountain brush, Douglas fir-white fir-blue spruce, and Engleman spruce-subalpine fir.

Desert shrub communities are sparsely vegetated shrublands that, depending on elevation and soils, may be dominated by shadscale (Atriplex confertifolia), fourwing saltbush (A. canescens), Castle Valley clover (A. cuneata) or mat saltbush (A. corrugata) and may include winterfat (Ceratoides lanata), Mormon tea (Ephedra spp.), budsage (Artemisia spinescens), miscellaneous buckwheats (Eriogonum spp.), Indian ricegrass (Oryzopsis hymenoides), galleta grass (Hilaria jamesii), grama grass (Bouteloua spp.), needle and thread grass (Stipa comata), sand dropseed (Sporobolus cryptandrus) and squirreltail (Sitanian hystrix). Greasewood (Sacobatus vermiculatus) - saltgrass (Distichlis stricta) may dominate bottomlands.

Many sagebrush communities of the area are relatively dense shrub stands of Artemisia tridentata with very little understory growth. In relatively undisturbed sagebrush communities, rabbitbrush (Chrysothamnus nauseosus or C. viscidiflorus), Mormon tea, and several perennial grasses may be common, including thickspike and western wheatgrass (Agropyron dasystachyum and A. smithii), basin wildrye (Elymus cinereus), Indian ricegrass and dropseed species.

In the sagebrush-grassland type, the typical big sage may give way to Artemisia tridentata var. vaseyana (mountain big sage) with a co-dominant perennial grass understory. Salina wildrye (Elymus salinus) may be co-dominant in these communities and may dominate an herbaceous grassland type. Black sage (A. nova) with Salina wildrye or western wheatgrass understory is also common.

Pinyon-juniper (Pinus edulis and Juniperus osteosperma) woodlands occupy drier sites, often with stony to very rocky soils. Pinyon and juniper are co-dominant in the overstory. Understory vegetation provides sparse to moderate ground cover. Range condition is poor to excellent condition. Understory species include sagebrush, mountain mahogany (Cercocarpus montanus), snowberry (Symphoricarpus oreophilus), and several perennial grasses including slender wheatgrass (Agropyron trachycaulum), Salina wildrye, junegrass (Koeleria cristata) and Indian ricegrass.

Dominant shrubs of the mountain brush communities will vary depending on elevation and aspect. The drier south and west-facing slopes may support dense stands of Gambel oak (Quercus gambellii). Other dominants of this community may include serviceberry (Amelanchier utahensis), mountain mahogany (Cercocarpus montanus or C. Ledifolius), bitterbrush (Purshia tridentata) and snowberry.

The range of the Douglas fir-white fir-blue spruce community is about 8,000 to 10,000 feet. Douglas fir (Pseudotsuga mensiesii) is usually the dominant tree with white fir (Abies concolor) and blue spruce (Picea pungens) usually limited to the most mesic sites, often along streams. With dense canopies, understory vegetation may be sparse. Common shrubs include serviceberry (Amelanchier spp.), Oregon grape (Berberis repens), chokecherry (Prunus virginiana), Rocky Mountain maple (Acer glabrum), mountain lover (Pachistima myrsinites) and snowberry. Bluebunch wheatgrass (Agropyron spicatum), mountain brome (Bromus carinatus), and Kentucky bluegrass (Poa pratensis) are common grasses. Stands of aspen (Populus tremuloides) can be found throughout the zone, particularly in mesic sites, and as successful communities.

Engelman spruce (Picea engelmannii) and subalpine fir (Abies lasiocarpa) dominate the spruce-fir zone at the highest elevations of the hydrologic impact area. While receiving about the same precipitation as the Douglas fir communities, lower vapor-transpiration with cooler temperatures can permit more lush vegetation in the spruce-fir zone. Limber pine (Pinus flexilis) often occupies steep or rocky, drier sites of this zone.

Small riparian communities are found at all elevations within the impact assessment area. With greater water availability and cooler temperatures, the riparian zone often includes more mesic species, (e.g., those from a higher vegetation zone). Shrub species from the mountain shrub type may be found at most elevations.

Additional riparian zone shrubs include Narrowleaf cottonwood (Populus angustifolia), red osier dogwood (Cornus stolonifera), skunkbush (Rhus trilobata), river birch (Betula occidentalis) and various willows (Salix spp.). Grass species from the mesic zones may be represented (mountain shrub and higher zones) along with fescues (Festuca spp.) and miscellaneous sedges (Carex spp). Small wet areas around springs and seeps will often support a dense growth of grasses, sedges and willows.

Aquatic Species - based on information in the USFS 1997 EA, pages III-14, 15 and 16

Some stream channels in the CIA support naturally-reproducing trout fisheries and typical coldwater, mountain-environment aquatic communities, including aquatic plants, insect populations, periphyton, and zooplankton. Information provided by the Utah Division of Wildlife Resources and cited in the EA indicates that in addition to trout, it is likely that there are speckled dace, mottled sculpin, bluehead suckers, and mountain suckers. It is likely adult cutthroat trout and sculpins are present in spawning habitats in headwater areas of the intermittent channels only during the spring reproductive period. The EA cites evidence that tiger salamanders, western toads, and Great Basin spadefoot toads probably inhabit the area.

High-gradient streams in the CIA are characterized by rock- and wood-created step-pools, deeply incised channels, and occasional beaver ponds. Riparian zones are composed of spruce-fir/aspen communities and thick willows. Spawning gravels are patchy and distributed in lower-gradient reaches. Successful spawning requires the presence of clean, well-oxygenated spawning gravels, so protecting these channels from excessive erosion and sedimentation is a high priority. In the past, stream channels throughout the area were degraded by livestock grazing and erosion from high runoff, such as occurred in 1983-84.

Small seep or pothole-type wetlands act as water reserves and provide baseflows that can support aquatic communities during low-water periods. Potholes, small ponds and marshy areas provide subsurface flow that supplements direct water sources like springs and run-off. These wet areas also provide important habitat for invertebrate and amphibian populations. Wet areas need to be protected from soil compaction, disturbance, and the removal of woody material to maintain existing habitat quality and quantity for aquatic organisms.

Geology

<u>Stratigraphy</u>

Consolidated strata exposed in the Wasatch Plateau Coal Field range in age from Late Cretaceous to Tertiary (Eocene), as seen in Figure 1 and Plate 3. The oldest exposed rocks are upper members of the Mancos Shale. The Cretaceous Mesaverde Group, which in the Wasatch Plateau consists of the Star Point Sandstone, Blackhawk Formation, Castlegate Sandstone, and Price River Formation, overlies the Mancos. Above the Mesaverde Group are the Paleocene North Horn Formation and Flagstaff Limestone of the Wasatch Group: the Flagstaff is the youngest and uppermost consolidated formation exposed in the CIA. Unconsolidated Quaternary colluvium, alluvium, and soils have been formed by weathering and erosion and are found on terraces, along canyon bottoms, and are especially prominent along the base of East Mountain in Joes Valley. Upper Cottonwood Canyon contains deposits of glacial till.

The stratigraphy displays an overall regressive sequence from marine (Mancos Shale) through littoral (Star Point Sandstone) and lagoonal (Blackhawk Formation) to fluvial (Castlegate Sandstone, Price River Formation and North Horn Formation) and lacustrine (Flagstaff Limestone) depositional environments. There are no major disconformities exposed in this area, but Spieker (1931, p. 42) considered the Castlegate-Blackhawk contact as likely unconformable in the Wasatch Plateau. Oscillating depositional environments within the overall regressive trend are represented by intertongueing lithologies, especially within the Blackhawk Formation and Star Point Sandstone. The Star Point consists of three main sandstone tongues - in ascending order, the Panther, Storrs, and Spring Canyon Sandstone Members.

The major coal-bearing unit in the Wasatch Plateau Coal Field is the Blackhawk Formation. The commercial coal seams are usually near the base of the Blackhawk, and in the East Mountain area the lowest seam, the Hiawatha, is often directly on or just above the Spring Canyon Sandstone. The Hiawatha Seam has been mined in the Crandall Canyon No. 1, Deer Creek, Des-Bee-Dove, Cottonwood-Wilberg, and Huntington #4 Mines. The Blind Canyon Seam has been mined at the Deer Creek, Des-Bee-Dove, and Huntington #4 Mines. Both seams will be mined in the South Crandall Canyon tract.

System	Series	Stratigraphic Unit			Thickness (feet)	Description
Tertiary	Eocene	Green River Formation			-	Greenish-gray and white claystone and shale, also contains fine-grained and thin-bedded sandstone. Shales often dark brown, containing carbonaceous matter. Full thickness not exposed.
	Paleocene	Colton Formation Flagstaff Limestone	Wasatch Formation		300 - 2,000 3,000 0 – 500	Colton consist of brown and dark-red lenticular sandstone, shale, and siltstone, thins westward and considered a tongue of the Wasatch. Wasatch predominantly sandstone with interbedded red and green shales with basal conglomerate. Found in east part of field and equivalent to Colton and Flagstaff in west. Flagstaff mainly gray and cream colored limestone, variegated shale, and fine-grained, reddish-brown sandstone.
Cretaceous	Danian	North Horn Formation *MINOR COAL*	Tucher Formation		350 – 2,500 0 – 200	North Horn Formation - Gray and gray-green calcareous and silty shale, tan to yellow-gray fine-grained sandstone, and minor conglomerate. Unit thickens to the west. Tucher Formation - Light gray to cream-white friable massive sandstone and subordinate buff to gray shale that exhibits light greenish cast. Contains minor conglomerate and probably represents lower part of North Horn, only present in east part of coal field.
	Maestrichthian	Price River Formation MINOR COAL		Mesaverde Group	500 – 1,500	Yellow-gray to white medium-grained sandstone and shaley sandstone with gray to olive green shale. Contains carbonaceous shale with minor coal and thickens along east edge of field.
	Campanian	Castlegate Formation *MINOR COAL*		Mesaverde Group	100 – 500	White to gray, fine-grained sandstone, argillaceous massive resistant sandstone thinning eastwardly with subordinate shale. Carbonaceous east of Horse Canyon but coal is thin and lignitic.

		Blackhawk Formation *MAJOR COAL SEAMS*			600 – 1,100	Cyclical littoral and lagoonal deposits with six major cycles. Littoral deposits mainly thick-bedded to massive cliff-forming yellow-gray, fine- to medium-grained sandstone, individual beds separated by gray shale. Lagoonal facies consist of thin- to thick-bedded yellow-gray sandstones, shaley sandstones, shale, and coal. Coal beds of Wasatch Plateau and Book Cliffs Coal Fields. Unit thins eastward, grading into the Mancos Shale.
		Star Point Sandstone			0 – 580	Yellow-gray, massive medium- to fine-grained littoral sandstone tongues projecting easterly, separated by gray marine shale tongues projecting westerly.
		Masuk Tongue	Mancos Shale		4,300 - 5,050	Gray marine shale, locally heavily charged with carbonaceous material, slightly calcareous and gypsiferous, nonresistant forming flat desert surfaces and rounded hills and badlands. Separated mainly to into tongues by westward projecting littoral; sandstone that eventually grade into shale. Sandstones are fine- to medium-grained, yellow-gray to tan, and medium-bedded to massive and cliff-forming.
		Emery Sandstone				
	Santonian					
	Coniacian	Garley Canyon Sandstone				
		Blue Gate Shale				
	Turonian	Ferron Sandstone *MINOR COAL*				
		Tununk Shale				
	Cenomanian	Dakota Sandstone			2 - 126	Heterogeneous sandstone, conglomerate, and shale, thin resistant cuesta former.

Figure 1 - General Stratigraphy of the Wasatch Plateau Coal Field (after Doelling, 1972)

Regional aquifer is a phrase commonly used by mine operators in the Book Cliffs and Wasatch Plateau coal fields. In such usage, regional aquifer usually refers to any water found in the Star Point Sandstone and Blackhawk Formation irrespective of quality, quantity, use, storage, flow and transport, and discharge. In preparing this CHIA, the Division has adhered to the definition of *aquifer* as found in the Coal Mining Rules (R645-100-200), and the term regional aquifer has been deliberately used or avoided, as appropriate, throughout this CHIA. Although there are local perched and fracture-related aquifers at East Mountain, the quality, quantity, use, storage, flow and transport, and discharge of ground water do not indicate the presence of a regional aquifer or aquifer system. After evaluating the geologic and hydrologic evidence, the Division does not consider the saturated strata in the Star Point, Blackhawk and associated formations in the East Mountain CIA to be a regional aquifer.

Hydraulic Conductivity and Permeability

In sedimentary rocks, there is a wide range of textures or fabrics that determine the hydraulic characteristics of the unfractured medium. These textures or fabrics are related to the mineralogy or composition of the sediments, the range of sizes of the sedimentary particles (sorting), the spatial distribution of different sediment-sizes (grading), the shape and spatial orientation or arrangement of the sediment particles after compaction (packing), cementation, and properties acquired or altered as and after the sediments were lithified. Lateral and vertical variations in these characteristics can create internal low-permeability zones or barriers, so that a unit that to the eye appears to be very uniform and to have aquifer characteristics can actually be incapable of storing or transporting water in any significant amount. Such vertical and lateral inhomogeneities are common within sandstone units of the Blackhawk and Price River Formations and in the Star Point Sandstone.

Based on slug tests and determinations from core samples, hydraulic conductivity of the Star Point Sandstone is typically low, so movement of ground water through the unfractured sandstone is slow and unfractured Star Point Sandstone is not generally considered to be an aquifer. However, hydraulic conductivity values within the Star Point Sandstone vary through several orders-of-magnitude, and unfractured units in the Star Point Sandstone can locally transmit sufficient ground water to sustain small springs or wells.

Strata above the Star Point Sandstone have hydraulic conductivities that are generally as low or lower than those in the Star Point Sandstone. As a very general rule-of-thumb, aquifers have hydraulic conductivities of 10^{-5} cm/sec or greater.

Table 3
Hydraulic Properties of Strata in the Wasatch Coal Field, Utah

			Price River	North Horn	Blackhawk	Star Point
USGS Lab Measurements on Cores (Lines 1985)		17-6 27bda *Horizontal*			Ss 1.5×10^{-2} ft/day ($\sim5.3\times10^{-6}$ cm/sec)	
					Silt 9.3×10^{-8} ft/day ($\sim3.3\times10^{-11}$ cm/sec)	
					Ss 1.1×10^{-2} ft/day ($\sim3.9\times10^{-6}$ cm/sec)	
					Shale 1.1×10^{-8} ft/day ($\sim3.9\times10^{-12}$ cm/sec)	
					Silt 2.0×10^{-7} ft/day ($\sim7.0\times10^{-11}$ cm/sec)	
						Ss 3.1×10^{-2} ft/day (1.1×10^{-5} cm/sec)
						Ss 1.5×10^{-2} ft/day (5.3×10^{-6} cm/sec)
		17-6 27bda *Vertical*			Ss 3.7×10^{-2} ft/day ($\sim1.3\times10^{-6}$ cm/sec)	
					Silt 1.2×10^{-11} ft/day ($\sim4.2\times10^{-11}$ cm/sec)	
					Ss 3.9×10^{-3} ft/day ($\sim1.4\times10^{-6}$ cm/sec)	
					Shale - Not measured	
					Silt 2.2×10^{-7} ft/day ($\sim7.8\times10^{-10}$ cm/sec)	
						Ss 1.1×10^{-2} ft/day (3.9×10^{-6} cm/sec)
						Ss $\times10^{-2}$ ft/day (2.3×10^{-6} cm/sec)
USGS Recovery or Drawdown Test (Lines 1985)		17-6 24dcd			2 ft^2/day ($2.2\times10^{-2}cm^2$/sec ~ 3.9×10^{-6} cm/sec)	
		17-6 27bda			8 ft^2/day ($8.6\times10^{-2}cm^2$/sec ~ 4.8×10^{-6} cm/sec)	
						6 ft^2/day ($6.4\times10^{-2}cm^2$/sec ~ 2.6×10^{-6} cm/sec)
		17-6 28bad	0.8 ft^2/day ($8.6\times10^{-3}cm^2$/sec ~ 5.6×10^{-6} cm/sec)			
		17-6 34dda		10 ft^2/day ($1.1\times10^{-1}cm^2$/sec ~ 7.8×10^{-5} cm/sec)		
					0.7 ft^2/day ($7.5\times10^{-3}cm^2$/sec ~ 1.6×10^{-5} cm/sec)	
		18-6 4bac			100 ft^2/day ($1.07cm^2$/sec ~ 5.8×10^{-5} cm/sec)	
Genwal Mine Slug Tests	Genwal MRP	MW-1 (1987)				0.1 ft/day (3.5×10^{-5} cm/sec)
		MW-4 (1992)				0.6 ft/day (2.1×10^{-4} cm/sec)
		MW-5 (1992)				2.5 ft/day (8.8×10^{-4} cm/sec)
	Mayo and Assoc. 1997c	MW-2 Spg Cyn				4.8 to 4.9×10^{-8} ft/sec (1.5×10^{-6} cm/sec)
		MW-6a Spg Cyn				4.4 to 5.9×10^{-8} ft/sec (1.3 to 1.8×10^{-6} cm/sec)
		MW-7 Spg Cyn				7.4×10^{-8} ft/sec (2.2×10^{-6} cm/sec)

Table 3
Hydraulic Properties of Strata in the Wasatch Coal Field, Utah

			Price River	North Horn	Blackhawk	Star Point
		MW-6 Panther				6.2 to 7.4x10^{-8} ft/sec (1.9 to 2.2x10^{-6} cm/sec)
Trail Mountain Mine		TM-3				5.1x10^{-3} cm/sec
Skyline Mine (Vaughn Hansen Associates 1979						
					2.4 ft^2/day (2.6x10^{-2} cm^2/sec)	
Bear Canyon Mine Slug Tests	Panther Tongue	DH-1A				5.5x10^{-1} cm^2/sec (2.6x10^{-4} cm/sec)
		DH-2				2.4x10^{-2} cm^2/sec (8.8x10^{-6} cm/sec)
		DH-3				7.4x10^{-2} cm^2/sec (3.4x10^{-5} cm/sec)
		DH-4				-
	Storrs Tongue	DH-1A				3.2x10^{-2} cm^2/sec (~1.1x10^{-5} cm/sec)
		DH-2				89.3 cm^2/sec (~2.7x10^{-2} cm/sec)
		DH-3				7.5x10^{-4} cm^2/sec (~2.8x10^{-6} cm/sec)
		DH-4				-
	Spring Canyon Tongue	DH-1A				1.4x10^{-1} cm^2/sec (~5.1x10^{-5} cm/sec)
		DH-2				1.5x10^{-2} cm^2/sec (~4.2x10^{-6} cm/sec)
		DH-3				4.0x10^{-2} cm^2/sec (~2.0x10^{-5} cm/sec)
		DH-4				3.1x10^{-1} cm^2/sec (~5.7x10^{-5} cm/sec)

l^2/t = transmissivity
l/t = hydraulic conductivity

Swelling Clays

The interbedded claystones, siltstones, and sandstones of the Wasatch Plateau are rich in swelling clay minerals of the montmorillonite or smectite group. Swelling clays absorb water and expand to as much as 150 percent of their dry volume. These swelling clays reduce the hydraulic conductivity of the rock or soil that contains them and contribute to the rapid closing or healing of tension fractures that result from subsidence. Genwal examined six shale and siltstone samples from the Blackhawk Formation by X-ray diffraction and cross-polarized light microscopy and found the samples contained 3 to 34 percent smectitic clays, with an average of 24 percent. Siltstones and shales in the Castlegate (three samples) averaged 19 percent smectitic clay, and the Price River Formation (three samples) 15 percent. Non-swelling clays, which also inhibit ground-water flow, constituted an additional 1 to 6 percent of the rock volume (Crandall Canyon Mine MRP, App. 7-41).

Coal

The Blackhawk Formation contains the economic coal resource in the Wasatch Plateau Coal Field. The Hiawatha and Blind Canyon are the only seams in the East Mountain area that can be mined economically. Coal washing facilities at the Hunter Power Plant allow lower-quality and higher-ash coal to be mined and used for power generation. The Cottonwood Seam, which lies between the Hiawatha and Blind Canyon Seams, has been determined by UP&L and the BLM to be unminable: temperatures indicate it may be burning in areas. The Bear Canyon Seam, which is above the Blind Canyon Seam in Crandall Canyon, is thick but not extensive enough to be mined economically.

The lowest coal seam is the Hiawatha, characteristically lying on or just above the Star Point Sandstone. This seam has been mined in the Cottonwood/Wilberg, Deer Creek, Des-Bee-Dove, Huntington #4, and Crandall Canyon No. 1 Mines. The Hiawatha Seam thins to less than 5 feet in the north end of the Cottonwood/Wilberg Mine, but then thickens again to the north, where it is mined in the Rilda Canyon area by way of rock slopes down from the Deer Creek Mine. Access to this seam in the Mill Fork Extension is by way of entries advanced from the Deer Creek Mine through the 65.7-acre lease modification added to Lease U-06039, and PacifiCorp's proposed Rilda Canyon portals will connect with these entries. The Hiawatha Seam reaches a thickness of 12 feet in the north workings of the Crandall Canyon Mine and over 6 feet where it will be mined in the South Crandall Canyon Tract.

The Blind Canyon Seam lies 40 to 100 feet above the Hiawatha Seam. The Blind Canyon Seam has been mined in the Deer Creek, Huntington #4, and Des-Bee-Dove Mines. This seam is too thin to be mined economically south of the Deer Creek Mine and in the area of the Crandall Canyon No. 1 Mine, but it will be mined in the Mill Fork Extension (up to 19 feet thick) and South Crandall Canyon tract (up to 7 feet thick). In both the Mill Fork Extension and South Crandall Canyon Tract, this seam will be accessed by way of rock slopes from the Hiawatha Seam.

Overburden thickness in areas where full-extraction mining has been done or is projected in the Deer Creek, Cottonwood/Wilberg, Des-Bee-Dove, and the Crandall Canyon No. 1 Mines is 200 to 2,600 feet. Where subsidence is projected for the Mill Fork Tract, overburden ranges from 900 feet in the South Fork of Crandall Canyon to 2,600 feet under East Mountain, and for the South Crandall Canyon Tract it varies from under 500 feet, near the coal outcrops, to 1,500 feet.

Structure

Cliffs, narrow canyons, and high plateaus characterize topography in the East Mountain CIA. Strata in the Wasatch Plateau were tilted in response to the rise of the San Rafael Swell and modified by subsequent tectonic, orogenic, and erosional events. Strike of the beds is generally parallel to the face of the Wasatch Plateau escarpment, and dip is usually less than 5 degrees, whether it is regional or caused by local structural deformation. Major structural features associated with East Mountain are:

- Flat Canyon Anticline;
- Crandall Canyon Syncline;
- Straight Canyon Syncline;
- Roans Canyon Graben;
- Mill Fork Fault Graben or Fault Zone;
- Deer Creek Fault;
- Pleasant Valley Fault; and
- Joes Valley Graben, Joes Valley Fault, and other related faults

All but the Flat Canyon Anticline are shown on Plate 3. PacifiCorp has mapped the Flat Canyon anticline as a gentle fold that begins at Joes Valley Fault and trends northeast and then north before dying-out in upper Mill Fork Canyon. The EA prepared by the USFS and BLM described this anticline as simply having a north-south orientation (p. III-3).

In the area of the Crandall Canyon No. 1 Mine, strata dip at less than 5^O on both flanks of a gently south-plunging, unnamed anticline that terminates in the Crandall Canyon Syncline. Because the axis of this fold is near Joes Valley Fault, the west flank of this anticline is limited in extent and may simply be a drag-fold caused by movement on Joes Valley Fault.

The Crandall Canyon Syncline is oriented northeast-southwest on the Joes Valley side of East Mountain but curves roughly 90^O and trends northwest–southeast where it crosses Little Bear Canyon on the Huntington Canyon side of the mountain. This syncline terminates at approximately a right angle against the Mill Fork Fault Graben, near Little Bear Spring.

Straight Canyon Syncline extends southwest to northeast from Trail Mountain, across Cottonwood Canyon, and then terminates between the upper forks of Meetinghouse Canyon. Its axis is just south of and parallel to Roans Canyon Graben.

Roans Canyon Graben is a series of several parallel normal faults, with four main faults. The graben extends from Trail Mountain to Meetinghouse Canyon. Maximum displacement on the faults is 150 feet. Where the Deer Creek Mine crosses the graben at the 3rd North crossing, strata north of the graben are 40 feet lower than those south of the graben and the floor of the graben has been dropped 114 feet. Gouge in the four main faults is absent at some locations and up to 30 feet thick at others (1988 PacifiCorp Annual Report). Experience in the Deer Creek Mine indicates the faults impede ground-water movement across the graben but facilitate flow parallel to the graben, both vertically and horizontally.

The Mill Fork Fault Graben or Zone is a northeast-southwest trending series of faults. PacifiCorp has mapped this zone as branching from the Roans Canyon Fault Graben at Trail Mountain and extending to Huntington Canyon. In places, the faults that mark this zone can be mapped from features visible at the surface, but the zone has been extended across the CIA based on underground encounters in the Deer Creek and Huntington #4 mines and a geophysical study performed by PacifiCorp in the Rilda Canyon area. Offset is approximately 25 to 30 feet on the faults bounding both sides of the graben. The faults are exposed in Little Bear Canyon, where Little Bear Spring flows from the bounding fault on the west side of the graben.

The Deer Creek and Pleasant Valley Faults trend north-south along the southeast side of East Mountain. They are representative of a series of en-echelon faults that extend from the south end of Gentry Mountain and across Huntington Canyon to East Mountain. These faults are the southern end of a group of major north-south faults that includes the Pleasant Valley, Trail Canyon, and Bear Canyon Faults. Layout of the Des-Bee-Dove Mines was dictated by a system of these north-south faults, and the Deer Creek Fault separates the Des-Bee-Dove Mines from the Deer Creek and Wilberg Mines. Fault displacements are generally less than 30 feet and not more than 200 feet.

Joes Valley lies west of East and Trail Mountains in Joes Valley Graben. Joes Valley Graben and its bounding faults are regional features that run north-south for roughly 80 miles and extend both north and south well beyond the geographic area named Joes Valley. Joes Valley Fault is the eastern edge of Joes Valley Graben. It is a normal fault with up to 3,000 feet of vertical offset, but maximum offset in the CIA is approximately 1,500 feet. The fault scarp has eroded to form the steep, western flank of East Mountain.

At the divide between Joes Valley and Scad Valley the elevation is 9,300 feet. From that divide Joes Valley slopes south to Joes Valley Reservoir, located several miles south of the CIA, where the elevation of the valley floor (now submerged below the reservoir) is 6,800 feet.

Upper Price River and North Horn Formation are exposed on Bald Ridge and Middle Mountain, which are fault-bounded blocks of bedrock exposed within Joes Valley Graben. Indian Creek flows in a narrow sub-drainage that lies between Joes Valley Fault on the east and Bald Ridge and Middle Mountain on the west. This drainage is surfaced with a westward thinning wedge of colluvium and alluvium from East Mountain that has been deposited over the North Horn Formation. Indian Creek does not flow down the middle of this drainage, rather, having been displaced by the alluvial-colluvial wedge, it flows on the west side of the valley, near the North Horn-alluvium contact at the base Bald Ridge and Middle Mountain.

Jointing, which affects hydrologic characteristics, is significant in the Mill Fork Lease area. As the Crandall Canyon Mine workings neared Joes Valley Fault, a series of subsidiary tensional fractures was encountered. The dominant joints parallel Joes Valley Fault, trending predominantly north-south to north 10^{0} east, and secondary fracture sets follow other orientations (Mill Fork Extension MRP, R845-301-624).

Climate

Temperatures range from 32^{O} to 90^{O} F in the summer and -10^{O} to 40^{O} F in the winter. Potential evapotranspiration has been estimated to be 18 to 21 inches per year (Crandall Canyon Mine MRP, p. 7-24). Prevailing winds are from the west and northwest. The average velocity at the Crandall Canyon Mine, based on information from the Utah State Climatological Office, is 12 mph (Crandall Canyon Mine MRP, p. 7-24).

Annual precipitation ranges from 10 to 30 inches per year in the CIA (Danielson and others, 1981). Table 4 shows variation is not strictly controlled by elevation; for example, the Crandall Canyon Mine averages 40 percent more precipitation than PacifiCorp's higher elevation East Mountain station. At the East Mountain station, there are two wet-dry cycles during the year: June is typically the driest month, with another dry period in December. Precipitation peaks in March and September, but no month averages over 1.5 inches. June is also the driest month at the Crandall Canyon Mine, but the five months from November through March each average over 2 inches of precipitation, with December averaging over 3 inches. August also has over 2 inches of precipitation from the late-summer so-called *monsoon* rains typical of the region.

Table 4
Annual Precipitation in the
East Mountain CIA Area

	Annual Precipitation (inches)	Water Years	Elevation (feet)	Source of Information
Crandall Canyon Mine	20	NA	8,000	Crandall Canyon Mine MRP, p. 7-24.
Hunter Power Plant*	8	1976 – 2001	5,800	2001 PacifiCorp Annual Report
Huntington Power Plant	10	1971 – 2001	6,500	
Electric Lake*	24	1971 - 2001	8,350	
East Mountain	14	1980 - 2001	9,000	

* - Located outside the East Mountain CIA

The East Mountain CIA straddles the boundary between Palmer Hydrologic Drought Index (PHDI) Regions 4 and 7 and is near Region 5; Figure 2 shows the PHDI for 1978 through 2004. The area was in a drought, at times extreme drought, from 2000 to the end of 2004.

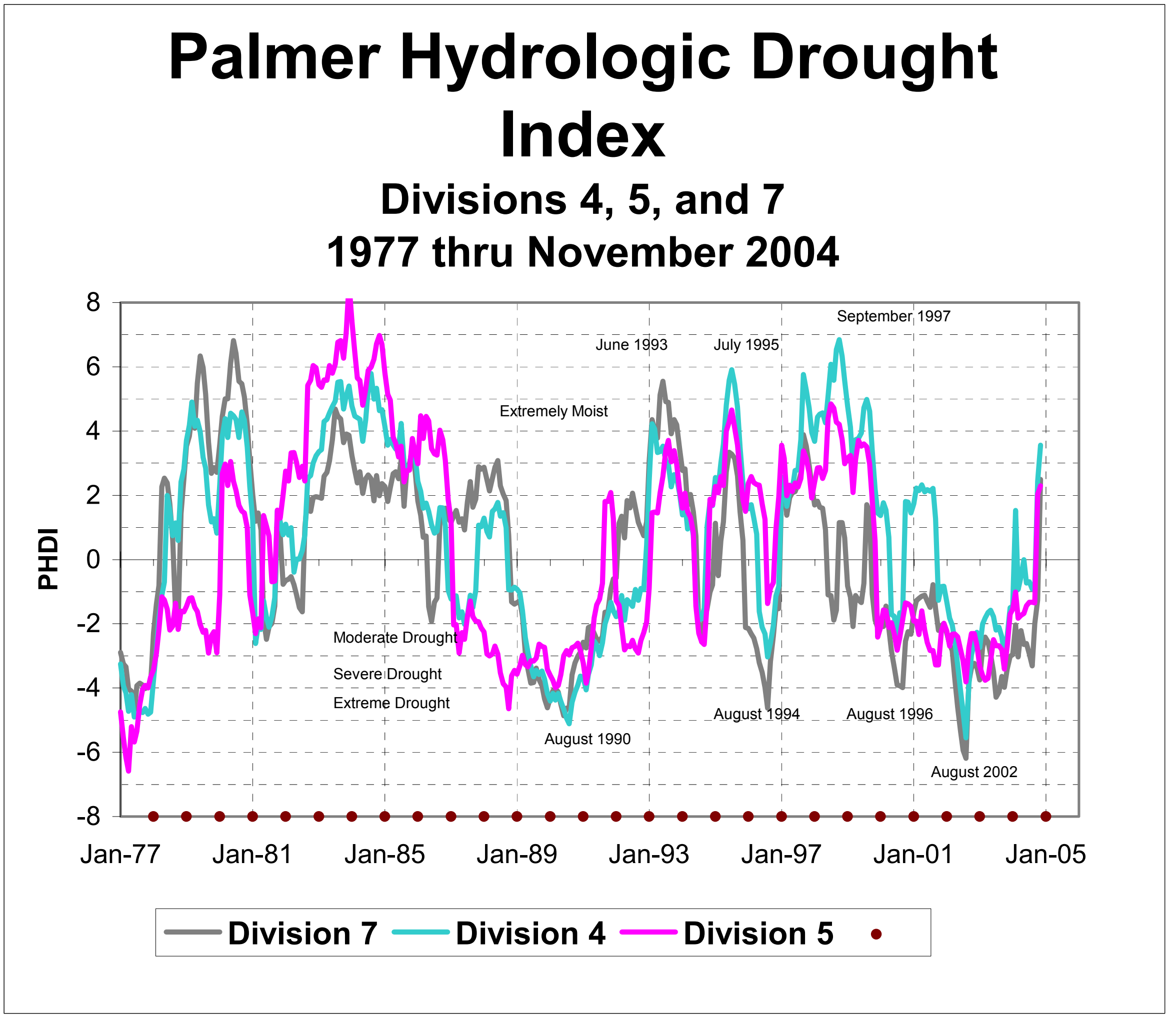

Figure 2 - PHDI, Divisions 4, 5, and 7

HYDROLOGIC SYSTEMS and USES

Ground Water

Ground-water regimes in the CIA are dependent upon climatic and geologic parameters that establish systems of recharge, movement, and discharge.

In the East Mountain CIA, snowmelt at higher elevations provides most of the water for ground-water recharge. Recharge has been estimated to be 3 to 8 percent (Danielson and Sylla, 1983) and 9 percent (Waddell and others, 1986) of the average annual precipitation for areas in the Wasatch Plateau and Book Cliffs coal fields. Well-developed soils and permeable or fractured lithologies exposed at the surface facilitate recharge.

Recent studies in Australia (Barnes and others, 1994) and at the Nevada Test Site (French and others, 1996) indicate that recharge is not a linear process in arid and semi-arid environments, but rather there are threshold conditions involving the soil and the amount, rate, and timing of precipitation that must be met before recharge occurs. Therefore, precipitation data can be used to estimate possible recharge, but used alone they may not accurately predict recharge: there can be years with precipitation but no recharge.

Once recharge enters the ground, the rate and direction of ground-water flow is governed mainly by gravity and geology. Lateral ground-water flow dominates in the gently-dipping Tertiary and Cretaceous strata of the Wasatch Plateau, where layers of low-permeability rock that impede downward movement are common. Both lateral and vertical flow may be channeled through faults and fractures, but plastic or swelling clays that can seal faults and fractures are abundant.

Ground water tends to flow more readily through shallower systems where weathering and fracturing produce hydraulic conductivities that are generally larger than in deeper systems. Much of the ground-water flow continues both laterally and downward through these shallower, local systems until it intercepts the surface and is discharged at a spring or seep, enters a stream as baseflow, is transpired by vegetation, or simply evaporates to the atmosphere. However, some of the ground water follows deeper and slower flow-paths where it becomes isolated from the surface and is, in effect, stored.

The Star Point Sandstone, Blackhawk Formation, Castlegate Sandstone, Price River Formation, North Horn Formation, Flagstaff Limestone, and Quaternary deposits are potential reservoirs or conduits for ground water in the CIA. Strata of the Mesaverde Group do not readily receive recharge from surface water because they are dominantly low-permeability claystones and siltstones. Large volumes of these rocks may be unsaturated or even dry.

In the Blackhawk, Price River, and North Horn Formations, higher permeability sandstones occur as lenticular and tabular channel and overbank deposits within a lower permeability claystone and siltstone matrix. The sandstones are laterally and vertically discontinuous and pinch-out over short distances, and individual sandstone units are poorly interconnected, isolated by the claystones and siltstones. However, these sandstones, especially where fractured, can produce significant ground-water flows from local systems.

Although the Star Point Sandstone is often characterized as a homogeneous sandstone body, it consists of three major sandstone members – Panther, Storrs, and Spring Canyon - intertongued with finer-grained rock. These major members can be further subdivided into coarser- and finer-grained units or sequences. As with the other strata, significant ground-water flows are usually associated with fractures.

There are some isolated Flagstaff Limestone outcrops on East Mountain that have reservoir properties which have developed through dissolution and fracturing.

As is typical of ground water throughout the plateaus and mountains surrounding the Price River basin, ground water in the CIA occurs under both confined and unconfined conditions. Shale, siltstone and cemented sandstone beds act as aquicludes to impede ground-water movement. Such localized aquitards occur within all stratigraphic units. The Mancos Shale is considered a regional aquiclude that limits downward flow within and adjacent to the CIA.

Piezometric data from the Crandall Canyon Mine indicate ground water in the Spring Canyon Member of the Star Point Sandstone moves from northwest to southeast, from the crest of East Mountain towards Huntington Canyon. The USGS has identified the Star Point and Blackhawk Formations as an aquifer (Danielson and others, 1981), and Lines (1984) designated these formations as a regional aquifer. *Regional aquifer* is a common phrase used by mining operators in the Carbon and Emery County coal fields. In such usage, regional aquifer usually refers to any water found in the Star Point Sandstone and Blackhawk Formation irrespective of quality, quantity, use, storage, flow and transport, and discharge. The Division has adhered to the definition of *aquifer* as found in the Coal Mining Rules (R645-100-200). Although there are local aquifers in the Star Point and Blackhawk strata, the Division does not consider the Star Point Sandstone and Blackhawk Formation in the East Mountain CIA to constitute a regional aquifer.

Faults and fractures can act as effective conduits for ground water and allow downward flow, even potentially bypassing unsaturated strata. Fractures in the Roans Canyon Fault Graben appear to act as significant vertical conduits for ground water. Drilling from within the Deer Creek Mine in advance of mining operations identified two major hydrogeologic units associated with the graben, and aquifer testing indicated a horizontal flow component, within the graben, towards the east with discharge into the Huntington Creek drainage (1988 PacifiCorp Annual Report).

Table 5
Spring Discharge Volumes in the
East Mountain CIA

Lithologic Unit	Number of Springs Listed by Permittees	Number of Springs Monitored	Total Average Monitored Discharge
Flagstaff Limestone	17	8	45 gpm
North Horn Formation	243	100	2,610 gpm
Price River Formation	127	34	109 gpm
Castlegate Sandstone	32	6	6 gpm
Blackhawk Formation	83	17	110 gpm
Star Point Sandstone	19	3	350 gpm
Alluvium	120	8	190 gpm
Total	641	167	3,420

There are numerous seeps and springs within the CIA. PacifiCorp identified 198 seeps and springs in and adjacent to the Mill Fork Tract in their 2000-2002 baseline survey, and another 83 are listed in Volume 9 of the Deer Creek, Des-Bee-Dove, Cottonwood-Wilberg, Trail Mountain PAP. The Crandall Canyon No. 1 Mine PAP lists 357 seeps and springs in Crandall and Horse Canyons. Between them, Genwal and PacifiCorp have monitored 167 springs and seeps (this undoubtedly double-counts some sites that have been monitored by both companies.) The discharge volumes given in Table 5 are very general because not all sources were monitored over the same time period; however, the total of the average discharges from the monitored springs appears to be on the order of 3,000 gpm. Based on data from the springs that have been monitored, spring discharge is distributed roughly as follows:

Water quality progressively decreases from the Flagstaff Limestone to the Star Point Sandstone.

The sandstones of the Star Point generally have low permeability and typically produce water where permeability has been enhanced by fracturing or weathering; however, culinary water-supply well MW-1 at the Crandall Canyon Mine flows from apparently unfractured Star Point Sandstone, from a zone noted by the driller as being coarser-grained than the rest of the unit (Crandall Canyon Mine MRP, p. 7-7). The water-bearing sandstone was 290 to 335 feet below the surface. When initially completed in March and April 1987, MW-1 flowed in excess of 175 gpm. However, intermittent flow, used for culinary water by the mine, was reported at 3.2 gpm in April 1987 and flowed from 0.5 to 1 gpm until 2002 when flow ceased. (Tritium and radiogenic carbon values have not been reported for this water.)

At an exploratory hole in Dairy Canyon (SE¼SE¼SE¼ Sec 3, T. 17 S., R 6 E.) on Trail

Mountain, water from the Blackhawk Formation flowed to the surface at 150 gpm from a depth of 129 feet, approximately 500 feet above the Star Point Sandstone (Davis and Doelling, 1977, p. 36). The Division has not located any other information on this bore hole and it's water.

Well TM-3 in Straight Canyon was completed through the Starpoint Sandstone by PacifiCorp in 1994. It is 1,300 feet from the nearest mine workings. This well flowed 25 gpm, and had a pressure head of 65 psi when completed. The head remained relatively constant until late 1996 but began to decline in November 1996, when gate entries for the 8th and 9th Right longwall panels were being opened. The 9th, 8th, and then 10th Right panels were mined beginning in March 1997 and the Trail Mountain Mine began discharging water to Cottonwood Creek in June 1997. The well eventually ceased flowing. The head in TM-3 has been recovering since 2001, when pumping from the mine ended, and the gauge was reinstalled in August 2003 because the water level was approaching the top of the casing, but as of the 1st quarter 2004 no pressure readings have been reported. Energy West personnel suspect trapped air is interfering with the gauge.

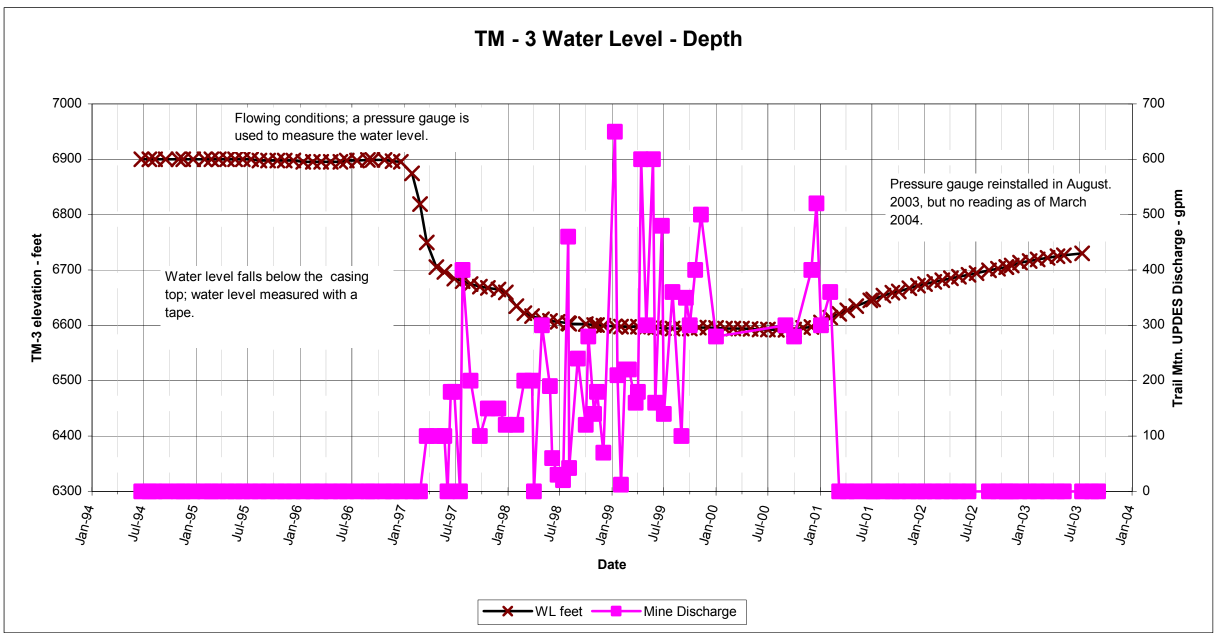

Figure 3 – Water level in well TM-3, adjacent to the Trail Mountain Mine

Mine Inflow

Water that flows into the mines in the CIA is ground water that has been stored in the adjacent Blackhawk Formation and Star Point Sandstone, including faults and fractures, or is actively flowing along faults and fractures. A substantial portion of the water that enters the mines is lost as water vapor during mine ventilation and extraction during the mining process as coal moisture content.

In the Crandall Canyon Mine, little water was encountered before 1996, and water was pumped from Crandall Creek to supply water for mine operations. In late 1996, ground-water inflow increased as mining progressed westward towards the fractured zone adjacent to the Joes Valley Fault and water no longer needed to be pumped into the mine; rather, excess water was discharged directly to Crandall Creek under a UPDES permit (UPDES Site 002). As shown in Figure 4, the mine operator reported monthly average discharges ranging from 90 to 700 gpm from November 1996 through 1999, and 900 to 1,200 gpm from January 2000 through December 2004. Water mainly dripped from fractures and channel sandstones exposed in the roof, but there was also slow leakage through the floor from the underlying Spring Canyon Member of the Star Point Sandstone.

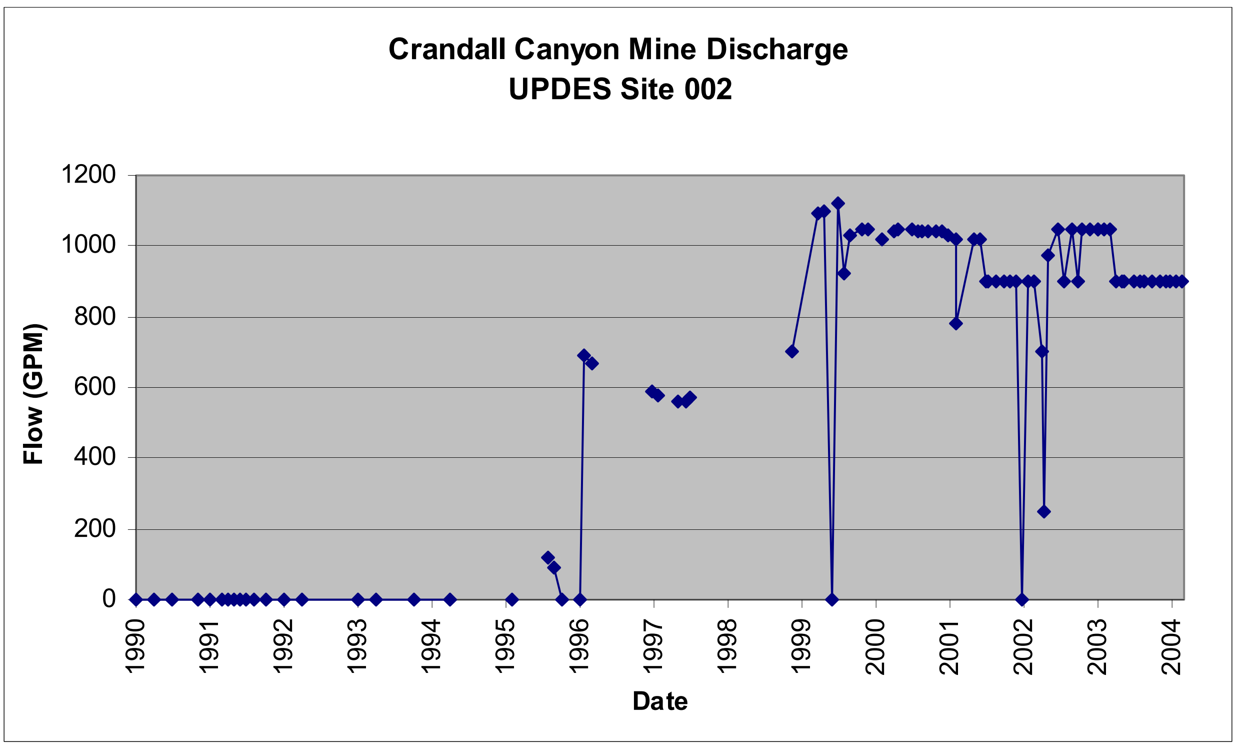

Figure 4 - Discharge of Crandall Canyon Mine

According to the Crandall Canyon Mine MRP and PHC, the estimated volume of water extracted by ventilation is approximately 50 to 60 gpm, and the volume lost due to coal moisture content is approximately 70 gpm.

Estimated inflow to all the PacifiCorp mines (2000 Annual Report) totaled 1.03 x10^9 gal., or roughly 2,000 gpm. Of this total, 57x10^6 gal. were discharged as water vapor during mine ventilation and 15x10^6 gal. diverted for various domestic uses in the mines. The remainder was discharged to the surface. (Mine water was never discharged at the Des-Bee-Dove Mines.)

At the Cottonwood/Wilberg Mine, estimated discharge to the Left Fork of Grimes Wash in 2000 was 52.9×10^6 gal (100 gpm). An estimated additional 23.3×10^6 gal (60 gpm) were consumed by mine operations and evaporation (2000 PacifiCorp Annual Report). The Cottonwood/Wilberg Mine was placed in temporary cessation in May 2001 and pumping within the mine and discharge to Grimes Wash ceased. The UPDES permit was modified and water now drains by gravity to the Trail Mountain Access Tunnel in Cottonwood Canyon, where it discharges to Cottonwood Creek. Discharge at the new point has averaged 28 gpm since June 2001.

The ventilation portals in Miller Canyon were permanently sealed in 1987, but 2-inch drainpipe was placed through one of the seals. The Miller Canyon portal area was reclaimed in 1999. A small volume of water still seeps out of the mine, bypassing the seals by way of sandstones that underlie the coal seam, but so far volumes have been too small to reach the UPDES monitoring point at the confluence of Miller Canyon with Cottonwood Creek (Cottonwood/Wilberg Mine MRP, Appendix XXII).

PacifiCorp has estimated that inflow to the Mill Fork Extension will be similar to what has occurred in the Deer Creek Mine, except interception of a fault zone is not expected. Where Deer Creek Mine operations intercepted open joint-systems in the Roans Canyon fault zone at two locations in the 4th North section in 1990, there were large ground-water inflows to the mine, estimated to be as much as 5,000 gpm. In 1992 the 4th South area was sealed and water production dropped significantly, but since then the rate of discharge has trended back up (Figure 5). PacifiCorp attributes this increase to several factors, but largely to mining having progressed into areas dominated by channel-sandstones in the roof. Between 1992 and 2001, discharge from the Deer Creek Mine averaged roughly 2×10^6 gal/day, or 1,400 gpm (2001 Annual Report). Total discharge in 2001 was estimated at 844.5×10^6 gal (1,600 gpm), a 14 percent increase from 2000. The average monthly discharge from May 2002 through September 2004 has ranged from 4 to 755 gpm, with an average discharge of 390 gpm during that time. An additional 25.3×10^6 gal (50 gpm) were consumed by mine operations and evaporation (2001 Annual Report). In the past, discharge from the Deer Creek Mine went directly to the Huntington Power Plant, but currently the power plant is not accepting water from the mine and all discharge goes to Deer Creek (Dennis Oakley – Energy West, personal communication, January 7, 2003).

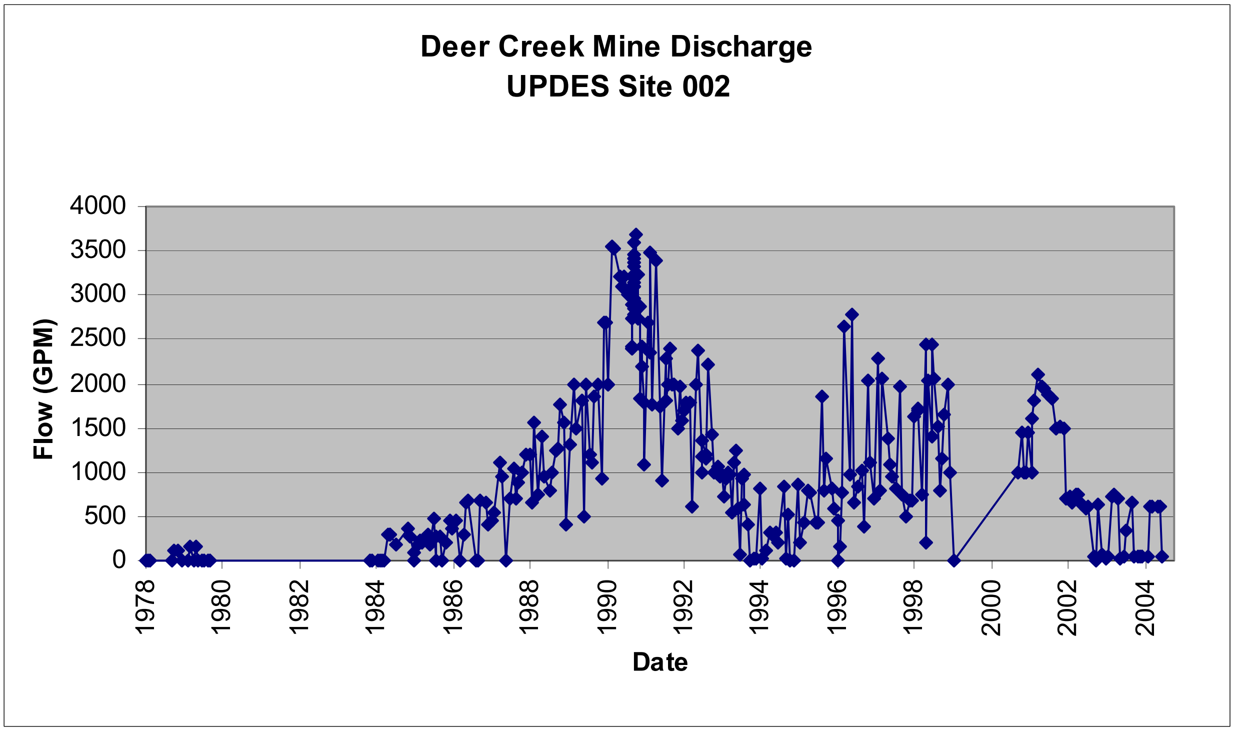

Figure 5 - Discharge of Deer Creek Mine

In the down-plunge end of the Straight Canyon Syncline, Trail Mountain Mine operations exposed the Spring Canyon Member. Ground water under pressure entered the mine at a rate of 200 to 300 gpm until the Spring Canyon Member was depressurized (Mill Fork Tract MRP, Appendix 700-B): the sandstone was not described as fractured.

The Huntington #4 Mine recovered Blind Canyon coal from within the Mill Fork Graben and northwest of the graben. Offset on the faults was approximately 25 to 30 feet on the bounding faults on both sides of the graben. Within the graben and at the bounding faults, only minor amounts of ground water were encountered (Deer Creek Mine MRP - Volume 12 Volume 12, Hydrology p. 51). Flow at Little Bear Spring was not measurably impacted: either the mine was above the potentiometric surface or there is an aquitard – perhaps one of the coal seams – that isolated the mine from the water.

Table 6 shows the estimated ground-water discharge rates and volumes for mines in the East Mountain CIA for 2004.

Table 6
Estimated Ground-Water Discharge in 2004
East and Trail Mountains

Mine	UPDES Discharge (gpm)	Evaporation and Extraction (gpm)	Yearly Total	
			(gallons/year)	(acre-feet/year)
Crandall Canyon Mine	900	120	536.1×10^6	1,645
Deer Creek Mine	390	50	231.3×10^6	710
Des-Bee-Dove Mines	0	0	0	0
Cottonwood/Wilberg Mine	28	0	14.7×10^6	45
Trail Mountain Mine	0	0	0	0
Total	**1,318**	**170**	**782.1×10^6**	**2,400**

Little Bear Spring

Little Bear Spring in Little Bear Canyon, east and south of the South Crandall Canyon lease, is an important source of water for the Castle Valley Special Services District (CVSSD), supplying 65 percent of the culinary water to the residents of Huntington, Cleveland, and Elmo. The only treatment required before use is chlorination. It is probably the largest and most consistently flowing spring in the region.

Little Bear Spring is on the south side of Little Bear Creek. It flows from the Panther Tongue of the Star Point Sandstone and appears to be issuing from a fracture that is the bounding fault on the northwest side of the Mill Fork Graben.

Several investigations - including isotope analyses (Mayo and Associates, 1997a and 1997d), geophysical studies (Sunrise Engineering, 2001a and 2001b; WTR, 1999), dye-tracer tests (Mayo and Associates, 2001c), and analyses of piezometric, chemical, and flow data - indicate that the one recharge area for Little Bear Spring, perhaps the principle recharge area, is upper Mill Fork Canyon. Precipitation runoff, snowmelt, and discharge from numerous springs collect in both the channel and alluvium of Mill Fork, and the water is diverted to Little Bear Spring through the Mill Fork Graben. PacifiCorp added a stream-monitoring point in Mill Fork, upstream of the Mill Fork Graben, at the request of the USFS.

However, earlier investigations of Little Bear Spring conducted prior to 1998 indicate a component of flow from the north or northwest. These hydrogeologic analyses concluded recharge was coming from the north, perhaps from Crandall Canyon or Huntington Creek and flowing along the Mill Fork Graben or faults parallel to it. During the review of the South Crandall Lease addition to the Crandall Canyon Mine, the USFS maintained that this northerly component of flow to Little Bear Spring was not eliminated as a possibility in later studies. In addition, more recent interpretations indicate fractures oriented north-south to northwest-southeast may provide some of the flow to the spring, 30 to 40 percent according to the 1998 AquaTrack study (WTR, 1998), but a recharge area has not been identified.

At Little Bear Spring, Danielson (Danielson and others, 1981) measured flows of 110 to 165 gpm between April 1978 and March 1979, apparently before the spring was developed as a culinary water source by CVSSD. CVSSD has measured flow at Little Bear Spring monthly since 1982, and regularly monitors the quality of the water. Recent water-quality and isotopic analyses (Mayo and Associates, 1997a) show the water from Little Bear Spring is similar to waters in Huntington and Little Bear Creeks. The high tritium and modern carbon in water from Little Bear Spring show the water is of modern origin, indicating regional flow through unfractured, low-permeability Star Point Sandstone is not a significant source of water for this spring.

Average flow measured by CVSSD has been approximately 340 gpm. Flow varies seasonally, one indication of a shallow-circulating ground-water system, but minimum flows have never dropped significantly below 190 gpm. This sustained baseflow indicates that the system has considerable storage capacity, probably in the channel-bottom alluvium of Mill Fork Canyon and in the fractures of the Mill Fork Graben, and possibly some in the Star Point Sandstone adjoining the fractures.

Because there a is a small possibility that mining in the Mill Fork tract or the Crandall Canyon lease area could impact some portion of the flow at Little Bear Spring, PacifiCorp and Genwal were required to develop water replacement plans before mining in the Mill Fork and South Crandall Canyon Extensions. Additional stipulations were placed on the federal lease for the South Crandall Canyon Extension by the USFS to reduce possible impacts from mining into fractures northwest of the Mill Fork Graben and Little Bear Spring.

Recharge to Little Bear Spring from unfractured Star Point Sandstone and Blackhawk Formation is generally discounted because of low hydraulic conductivity and permeability (Mayo and Associates, 1997c); however, even with low permeabilities, the large area exposed by the fractures in the graben could provide some recharge to Little Bear Spring from these formations. The down-plunge end of the Crandall Canyon Syncline could concentrate or enhance ground-water flow where it intercepts the Mill Fork Graben between Mill Fork and Little Bear Canyons.

Rilda Canyon Springs

North Emery Water Users Special Service District (NEWUSSD) has developed springs in lower Rilda Canyon to provide domestic and industrial water for areas outside the cities of Huntington, Cleveland, and Elmo. Studies performed by PacifiCorp indicate that approximately 80 percent of the recharge to these springs originates in the Right Fork of Rilda Canyon.

Studies have been proposed by PacifiCorp to see if the NEWUSSD collection system can be relocated in the Right Fork, which would move the collection system away from the access and ventilation portals proposed by PacifiCorp for Rilda Canyon.

Joes Valley

Joes Valley Fault separates Joes Valley from the coal mining activities at East and Trail Mountains. Joes Valley Fault is a normal fault with up to 3,000 feet of vertical offset, downthrown on the west side, but maximum offset within the CIA is approximately 1,500 feet. The fault forms the eastern side of the Joes Valley Graben and produced the steep western flank of East Mountain. Joes Valley Graben is a regional feature that runs north-south for roughly 80 miles and extends well beyond the East Mountain CIA.

The Blind Canyon and Hiawatha Seams in the East Mountain mines are several hundred feet lower in elevation than the adjacent floor of Joes Valley.

Indian Creek drains the section of Joes Valley adjacent to East Mountain. Upper Price River Formation crops out just to the north, in Scad Valley, but the floor of Joes Valley along Indian Creek consists of North Horn Formation overlain by a westward thinning wedge of alluvium and colluvium that was shed from the west flank of East Mountain. Indian Creek does not flow down the middle of this drainage, rather, having been displaced by deposition of the wedge of sediments, it flows on the west side of the valley at the base of Bald Ridge and Middle Mountain. Springs in the Indian Creek drainage flow mainly from the alluvium or from the North Horn Formation exposed west of the creek. Wetlands in the Indian Creek drainage are supported in part by ephemeral flows from the west flank of East Mountain. These wetlands often support diverse communities of amphibians, macroinvertebrates, and other flora and fauna.

Springs also flow in the small canyons that have been eroded into the west flank of East Mountain. These springs appear to be less numerous to the north, at the Crandall Canyon Mine where the Joes Valley Fault and the mountain ridge are close to each other, and to become more numerous towards the south as the distance between the scarp and ridge increases. This indicates ground-water flow to these springs is most likely related to the amount of adjacent surface area exposed for recharge (Deer Creek Mine MRP, Volume 12, Plate 1 and Drawing MFU1823D).

Three samples of water were collected inside the Crandall Canyon Mine in 1997: two from fractures that were encountered where Main West and 5th West approached Joes Valley Fault, and one from in-mine well MW-7, which was drilled to the Star Point Sandstone from a location in Main West approximately 200 feet from the fault. Water quality and age were determined for these samples. There was a small amount of tritium (0.95 TU) in the 5th West sample but none in the other two. Mean residence time determined from radiocarbon dating was 2,000 to 5,000 years. Based on these analyses, mining near Joes Valley Fault could intercept modern water recharged from the surface, but this so-called *active* zone near the fault will also yield deeper, older water (Mayo and Associates, 1997a; Deer Creek Mine MRP, Volume 12, Appendix B). A stipulation in the Mill Fork tract coal lease does not allow full extraction mining within a 22 degree angle-of-draw of the fault. Mining projections show no full-extraction mining within 400 feet of the projected fault trace, although bleeders and entries may intercept the fault.

Surface Water

Surface runoff from the east side of the Wasatch Plateau flows either to the Price River or San Rafael River. The Price River Basin, which includes about 1,800 square miles in six counties, is located primarily in Carbon and Emery Counties in east-central Utah. Headwaters of the Price River are the drainages around Scofield Reservoir and Soldier Summit. The river flows southeasterly and joins the Green River approximately 15 miles north of the town of Green River, Utah. The drainage is bounded by the Book Cliffs on the northeast, the Wasatch Plateau on the west and the San Rafael Swell on the south.

All drainage from the East Mountain CIA flows to the San Rafael River. The San Rafael River Basin lies south of the Price River Basin. This basin includes about 2,300 square miles in three counties, but is located mainly in Emery Country. The San Rafael River Basin occupies part of two physiographic sections of the Colorado Plateau - the High Plateaus to the north and west and Canyonlands to the south and east (Fenneman, 1946). Headwaters extend for 40 miles along the high central ridges and peaks of the Wasatch Plateau. Principal streams in the basin are Huntington and Cottonwood Creeks, which merge to form the San Rafael River, and Ferron Creek, which joins the San Rafael River within a mile of the Cottonwood - Huntington confluence. The San Rafael River also flows in a southeasterly direction to eventually join the Green River.

The CIA can be subdivided into 15 drainage basins as shown on Plate 4. Crandall, Little Bear, Mill Fork and Rilda Creeks drain the east side of East Mountain, flowing generally from west to east to Huntington Creek. Cottonwood Creek flows down Cottonwood Canyon between Trail and East Mountains, and the west slopes of East and Trail Mountains drain to Indian Creek through a number of short but steep tributaries. Indian Creek flows south to Lowry Water and then to Joes Valley Reservoir, which discharges to Cottonwood Creek by way of Straight Canyon.

Sixty-five percent of runoff in Huntington Creek occurs from April to July as a result of snowmelt. Water-content of the April 1 snowpack correlates well with annual discharge (Danielson and others, 1981, p. 11).

Under the Standards of Quality for Waters of the State of Utah (UC R-317-2), waters in Huntington and Cottonwood Creeks and their tributaries are classified as 1C, 2B, 3A and 4.

- 1C - protected for domestic use with prior treatment,
- 2B - protected for recreational uses except swimming,
- 3A - protected for cold water aquatic life, and
- 4 - protected for agricultural uses.

All waters on USFS lands are designated as High Quality Water Category 1 (no point-source UPDES discharge allowed), except part of Deer Creek is designated as High Quality Water Category 2 (UPDES discharge permitted but no degradation of quality allowed).

Water quality of both the Price and San Rafael Rivers is good in the mountainous headwater tributaries, but deteriorates rapidly as flow traverses the Mancos Shale. The shale lithology typically has low permeability, is easily eroded and contains large quantities of soluble salts that are major contributors to poor water quality. Depending on the duration of contact, water quality degrades downstream to where Total Dissolved Solids (TDS) levels of 4,000 mg/L are not uncommon. The predominant ion leached from the Mancos Shale is sulfate (SO_4) with values over 1,000 mg/L common in the lower reaches of the Price River.

Left Fork of Huntington Creek (1)

This drainage, including the major tributary, Scad Valley Creek, delineates the north and northwestern-most boundary of the CIA. There is little, if any, surface or subsurface drainage to these waters from areas potentially affected by any mine operations.

Horse Canyon (2)

Horse Canyon drainage encompasses approximately 2,700 acres. The canyon stream consists of intermittent and perennial sections and is divided into two forks; the main fork and the south fork. The stream flows east into Huntington Creek and is perennial downstream of where the two forks join. The main fork is considered intermittent above where the stream forks and the south fork is considered perennial for approximately one mile above where the stream forks. The south fork flows almost entirely within the Crandall Canyon Mine permit area. The mine permit limits retreat mining within the stream buffer zone of the perennial section.

Blind Canyon (3)

Blind Canyon drainage encompasses approximately 1,140 acres. The upper reaches of Blind Canyon Creek are intermittent and become perennial within approximately one mile of Huntington Creek. The creek is mostly intermittent within the Crandall Canyon Mine permit area, with approximately ¼ mile of the perennial portion extending into the permit area. In July 1991 Genwal installed a 12-inch parshall flume near the mouth of Blind Canyon. As of November 2004, maximum flow was 488 gpm (May 2002), but the stream has frequently been dry. TDS has ranged from 234 to 450 mg/L, and TSS from below detection to 54 mg/L.

The coal beneath Blind Canyon has been retreat mined and the effects of subsidence on watershed erosion and stream flow were to have been studied under the direction of the USFS Intermountain Research Station. In addition to determining effects of retreat-mining induced subsidence on stream flow and interconnectivity of surface and ground water, goals were to determine changes in channel relief and morphology, watershed erosion, and sediment routing. The final report was due September 1995. The Division has never received the report on this study, and the study –(or at least the final report) may have never been completed.

Shingle Creek Canyon (4A)

Shingle Creek Canyon is a smaller drainage encompassing 480 acres with an intermittent stream flowing east into Huntington Creek. The upper reaches of the stream branch into two forks; the left and right forks. Both of the forks extend into the Crandall Canyon Mine permit area as part of a 120-acre addition to Lease U-68082. A stipulation of the lease agreement (Special Coal Lease Stipulation #1) states that full extraction mining will not be authorized with overburden less than 50 times the thickness of coal removed plus 50 feet (projected to be 300 feet in the lease modification area).

Crandall Canyon (4)

Crandall Canyon drainage encompasses approximately 3,580 acres. The Crandall Canyon Mine underlies 2,145 acres of the drainage (including 330 acres of the South Crandall Canyon lease area), and the Mill Fork Lease underlies 1,120 acres. The average gradient of Crandall Creek is 16 percent. The channel immediately below the mine is described as steeper than 4 percent, and it has a boulder or bedrock channel (EA 1997, p. III-5). Crandall Creek flows east into Huntington Creek and is considered perennial from approximately ¾ mile up each of its two main forks to the confluence with Huntington Creek.

The USGS measured streamflow at station 09317919 at the mouth of Crandall Canyon on a seasonal basis –(typically May through November) 7 for water years 1977 to 1984. Daily mean streamflow ranged from no-flow (for one week) in November 1977 to 88 cfs (39,512 gpm) in May 1983, and averaged 5.4 cfs (2,425 gpm). Except for the winter of 1978-1979, values for flow were not reported during winters, presumably because the gauge and stream were frozen:

during the 1978 - 1979 winter, flow was 0.4 to 0.9 cfs (180 to 404 gpm). About 80 percent of streamflow in Crandall Creek occurs between April and July as a result of snowmelt, peak flow usually occurring in late May. Suspended sediment concentration in Crandall Creek in 1978 and 1979, when there was no mining in the canyon, ranged from 15 to 60 mg/L, which equaled a calculated daily load of 0.08 to 0.41 tons/day (Danielson and others, 1981, p. 17).

Genwal has measured water quality at sites located upstream and downstream of the mine since October 1983. The flumes equipped with automatic continuous recorders were installed in 1986: flow values were reported for most months between March 1988 and December 1992, and have been reported quarterly since. Before 1996 water was pumped from Crandall Creek to supply water for mine operations, which partially explains why during that time the measured average flow was greater above the mine than below (Table 7). Periodically the stream experiences extremely high flows from snowmelt or thunderstorms.

Table 7
Measured Flow in Crandall Canyon Flumes
(1986 - 1995, and 1996 - 2004)

Time Interval	Site ID	Flow in gpm		
		Min	Max	Avg.
07/86 – 12/95	UPF	0	12,023	1,090
	LOF	0	6,890	647
03/96 – 12/04	UPF	1.5	12,930	800
	LOF	4.2	10,156	1,125

UPF – Upper Crandall Canyon Creek Flume
LOF - Lower Crandall Canyon Creek Flume

The Crandall Canyon Mine facility is in the lower reaches of the canyon and consists of approximately 11 acres of surface disturbance. Several hundred feet of the Crandall Creek channel has been diverted through a culvert beneath the mine pad. All surface disturbance is treated by maintained sediment controls. Because Crandall Creek has a boulder and bedrock channel, there have been no observed changes to the channel morphology from the discharge of mine water to the creek.

Little Bear Canyon (5)

Approximately 820 acres are drained by Little Bear Canyon. The average gradient of Little Bear Creek is 30 percent. The South Crandall Canyon tract includes approximately 360 acres in Little Bear Canyon. Little Bear Creek is considered ephemeral and intermittent upstream of Little Bear Spring (located approximately ½ mile from the confluence with Huntington Creek), and perennial downstream of the spring. The USFS considers the creek to be ‘functionally perennial’ throughout much of the creek in that sufficient water flows subsurface in the alluvium to support riparian vegetation. Because of USFS concerns on the effects of subsidence to Little Bear Creek and its associated ecosystem within the South Crandall Canyon Lease, a lease stipulation was added to prevent subsidence in the Little Bear Canyon area with overburden less than 600 feet unless it can be demonstrated that the effects of subsidence would be negligable (Special Coal Lease Stipulation #9).

The Castle Valley Special Service District (CVSSD) diverts 200 to 400 gpm from Little Bear Spring, which provides culinary water to nearly 2,500 residents in the towns of Huntington, Cleveland and Elmo. The flow from Little Bear Spring is perennial and has not dropped below 190 gpm since CVSSD began keeping records in 1982. Flows in Little Bear Creek in 1978 and 1979, measured by Danielson at the point the stream discharges to Huntington Creek, are shown in Table 8 (Danielson and others, 1981). However, it is not known if Little Bear Spring was being diverted at the time Danielson made these measurements.

Table 8
Flow in Little Bear Stream
Measured by Danielson (1981)

Date	Flow	
	cfs	gpm
October 13, 1978	0.24	108
October 18, 1978	0.5 (est.)	224
July 19, 1979	1.0	449
October 16, 1979	0.75	337
October 30, 1979	0.24	108

The USFS excluded the area covered by the South Crandall Canyon Coal Lease Tract from the Mill Fork Lease because of concerns for potential adverse impacts to Little Bear Spring. The South Crandall Canyon area was reevaluated, and based on a Decision Notice/Finding of No Significant Impact (DN/FONSI) signed by the BLM and USFS in February 2003, the South Crandall Canyon Tract was leased through competitive bid to Andalex in 2003. A stipulation of the lease agreement (Special Coal Lease Stipulation #17) states "In order to adequately protect flow from Little Bear Spring, the Lessee must enter into a written agreement with Castle Valley Special Services District (CVSSD) to assure an uninterrupted supply of culinary water equivalent to historical flows from the spring. The agreement must be in place prior to mining." A water treatment plant is to be constructed under the provisions of an agreement between Genwal, Pacificorp, and the Castle Valley Special Service District. A copy of the agreement that meets the requirements of Special Coal Lease Stipulation #17 is included as Appendix 7-51 of the Crandall Canyon Mine MRP.

Mill Fork Canyon (6)

Approximately 3,960 acres are drained by Mill Fork Canyon. The average gradient of Mill Creek is 13 percent. PacifiCorp leases cover approximately 2,300 acres in Mill Fork Canyon but do not extend into Little Bear Canyon.

The old Huntington #4 Mine underlies approximately 1,300 acres in Mill Fork and Little Bear Canyons. The 12 acres of surface disturbance for the #4 Mine, all in Mill Fork Canyon, has been reclaimed and bond has been released.

Mill Creek is considered perennial in its lower reaches. Field observations by USFS personnel in August 1996 found that Mill Fork Creek was dry at the lower forks in Section 17, T. 16 S., R. 7 E., but flow was observed emanating from the creek bottom approximately 0.5 mile downstream of the forks. In the seep and spring inventory done by Genwal for the EA, 49 springs in the head of Mill Fork Canyon were identified. Flows ranged from seeps to 50 gpm, with most flows below 5 gpm (EA 1997, p. III-6). The occurrences were classed as follows:

Table 9
Springs in upper Mill Fork Canyon

Flow in gpm	Number of Springs
>25	4
20-25	0
15-19	4
10-14	5
5- 9	7
0- 4	29

Utah Division of Wildlife Resources has identified cutthroat and rainbow trout in Mill Fork and Little Bear Creeks, and considers these streams likely habitat for non-game fish as well (Deer Creek Mine MRP, Volume 12, p. 3-7).

Rilda Creek (7)

Lower Rilda Creek has historically been a perennial stream, mainly due to several large springs found in the middle reaches of the creek just below the confluence of the left and right forks. Several of these large springs have been developed by NEWUSSD, so some of what naturally flowed down the stream is now diverted for use in the NEWUSSD culinary water system. The average gradient of Rilda Creek is 11 percent.

Rilda Canyon drains approximately 5,100 acres, and the PacifiCorp permit area covers 3,600 acres of this drainage. The Right Fork drains about 2,114 acres and is the larger of the two main forks. The Left Fork joins the Right Fork above the NEWUSSD springs. Studies performed by PacifiCorp indicate that approximately 80 percent of the recharge to these springs originates in the Right Fork of Rilda Canyon.

Flow is measured at six locations, which are shown on Plate 6. Maximum, minimum, and average flow for the streams and NEWUSSD springs are summarized in Table 10.

Table 10
Rilda Canyon Flow

ID in Database	Description	First and Last Measurement		Flow in gpm		
				Min	Max	Avg.
RCF-1	Upper Right Fork Flume, just downstream of the Mill Fork Graben	4/89	6/04	0	4,500	410
RCF-2	Flume Above the NEWUSSD Springs	4/89	6/04	0	5,100	334
RCF-3	Flume Below the NEWUSSD Springs	4/89	6/04	0	5,050	370
RCW-4	Flume Above the confluence with Huntington Creek	4/89	6/04	0	7,000	426
RCLF-1	Lower Left Fork	4/90	6/04	0	400	19
RCLF-2	Upper Left Fork	10/95	6/04	0	160	18
NEWUA Meter-2	Combined flow from Side Canyon and South Spring.	9/90	6/04	0	20	4
NEWUA Meter-3	Collection system from the central area. Includes old Meter #4 flow.	9/90	6/04	30	220	93

Genwal's spring and seep inventory found 41 springs and seeps in the Right Fork of Rilda drainage, 25 of which reached the stream (EA 1997, p. III-7). The occurrences were classed as shown in Table 11.

Table 11
Springs and Seeps in the Right Fork of Rilda Canyon

Flow in gpm	Number of Springs
>25	4
20-25	3
15-19	4
10-14	7
5- 9	4
0- 4	19

Near the NEWUSSD springs, surface disturbances from the Helco, Jeppson, Rominger, and Leroy Mines were reclaimed by the Division's Abandoned Mine Reclamation Program (AMRP) in 1988 through 1991, with additional reclamation work done in late 2002. Construction of new portals and a bathhouse in Rilda Canyon has been discussed with the Division, BLM, USFS, US Fish and Wildlife Service, and Utah DWR and Energy West has submitted plans to the Division. The disturbed area will be approximately 12 acres, 3 acres being for topsoil and subsoil storage. The sedimentation pond will be on land previously disturbed by the Leroy (Comfort) Mine. Current projections are that these new portals will not be used for coal transport but will be used only for ventilation and transportation of workers and materials into the mine.

Meetinghouse Canyon (8) and Deer Creek Canyon (9)

Meetinghouse Creek is considered ephemeral and Deer Creek is considered perennial. The average gradient of Meetinghouse Creek is 12 percent and the average gradient of Deer Creek is 13 percent. The approximate areas of Meetinghouse and Deer Creek Canyons are, respectively, 5,500 acres and 4,000 acres: PacifiCorp's permit area includes approximately 5,000 acres in Meetinghouse Canyon and 3,700 acres in Deer Creek Canyon.

Deer Creek Mine operations have disturbed approximately 30 acres in the middle of Deer Creek Canyon. Runoff from surface facilities is treated by sediment controls. All coal produced at the mine is conveyed to the Huntington Power Plant, which is located near the bottom of Deer Creek Canyon and adjacent to Huntington Creek.

Discharges from the Deer Creek Mine have averaged 1,400 gpm, and the maximum reported discharge was 3,680 gpm in December 1990. Prior to December 1990, all discharge was piped to the Huntington Power Plant and none entered the natural drainages. A temporary discharge permit was issued in November 1990 because of high inflows into the mine at the Roans Fault crossing, and 1990 and 1991 was a period of consistently high discharge rates (Figure 4). Currently, the power plant is not accepting water from the mine (Dennis Oakley – Energy West, personal communication, January 7, 2003). Water is now diverted to abandoned mine sections and used underground for mine operations, and only excess water is discharged directly to Deer Creek at UPDES discharge point UT0023604-002: excess water from the Mill Fork Extension will also be discharged through this point.

Table 12
Flow in Deer Creek

ID in Database	Description	First and Last Measurement	Flow in gpm		
			Min	Max	Avg.

DCR01	Deer Creek above the mine.	5/78	6/04	0	2,900	150
DCR04	Deer Creek as it leaves the permit area	6/84	6/04	0	2,900	620
DCR06	Deer Creek at confluence with Huntington Creek	5/78	6/04	0	2,900	530

Maple Gulch (10) and Danish Bench (11)

Approximately 5,400 acres of Maple Gulch and 4,600 acres of the Danish Bench drainages are associated with the CIA. Both areas are primarily Mancos Shale flats draining away from the southern end of East Mountain; therefore steep, deeply incised canyons are not as prominent as in the other drainages in the CIA. Danish Bench drains to Cottonwood Creek with an average gradient of 12.5 percent. Maple Gulch drains to Huntington Creek and has an average gradient of 17 percent. Permitted areas of the PacifiCorp mines encompass 840 acres of Maple Gulch and 250 acres of Danish Bench. The Des-Bee-Dove underground workings are beneath Maple Gulch drainage, and there are reclaimed ventilation portals in Maple Gulch.

Grimes Wash (12)

Grimes Wash drainage has an area of approximately 8,400 acres, 4,600 of which are in PacifiCorp's permit areas. The average gradient of Grimes Wash is 14 percent.

Cottonwood/Wilberg Mine surface facilities are located in Grimes Wash. There are 31 acres of surface disturbance, with a sedimentation pond and other and sediment controls to treat runoff from the disturbed area.

The Des-Bee-Dove mine portals, located at the head of a small, narrow canyon in the Grimes Wash drainage, disturbed 24 acres. Reclamation of the Des-Bee-Dove mines began in 1999 and grading and reseeding were completed in 2003. The sedimentation pond will possibly be removed in 2005 if RUSLE modeling indicates the reclamation sediment control measures are adequate to control erosion and sedimentation.

Cottonwood Creek (13)

This area encompasses approximately 11,000 acres that drain to Cottonwood Creek along the southwest edge of the CIA. The portion of PacifiCorp's permit areas contained in this drainage is approximately 5,200 acres. The Cottonwood Creek drainage has many small tributary canyons.

This drainage contains 12 acres of surface disturbance associated with the never-completed Cottonwood Fan Portal of the Cottonwood/Wilberg Mine. The disturbed area has been reclaimed, and Phase I reclamation bond release was completed in 2003.

There are also three reclaimed Cottonwood/Wilberg portals in Miller Canyon, a side canyon to Cottonwood Creek. Although the portals are sealed, drainage in the mine apparently accumulates behind the seals and periodically discharges through the sandstones that underlie the coal seam. The discharge drains to Miller Canyon and potentially can reach Cottonwood Creek. There is a UPDES discharge point where the Miller Canyon stream meets Cottonwood Creek, but, to date, the discharge has been insufficient to reach that point. In addition to the UPDES monitoring, the USFS stipulated sampling of any water at the sealed portals in June and October of 2002 and 2003, but only one time was there sufficient water to collect a sample.

<u>Indian Creek (14)</u>

The EA (p. III-7) reported that the USFS measured Indian Creek flows ranging from 1 cfs to 30 cfs (450 to 13,500 gpm) from 1972 to 1975. Since 1996, Genwal has monitored Indian Creek quarterly at a flume located approximately one-half mile south of the USFS guard station, next to the east-west road that crosses the creek (near the common corner of Sections 15, 16, 21, and 22, T. 16 S., R. 6 E.). The flume is usually inaccessible during the end of the fourth quarter and the entire first quarter. Measured flow has ranged from 0.0 gpm in March 1998 to 7,070 gpm in October 1996.

Numerous short, steep unnamed channels or gulleys carry precipitation and snowmelt runoff down the west side of East Mountain to Indian Creek. These ephemeral drainages not only provide seasonal flow directly to Indian Creek but also recharge the alluvial and bedrock aquifers that provide baseflow throughout the year. The valley contains several marshy wetland areas along the stream.

Water draining from East Mountain could be intercepted if subsidence were to localize along Joes Valley Fault or if ground movement produced fractures at the surface. A stipulation in the Mill Fork Tract lease does not allow full extraction mining within a 22 degree angle-of-draw of the fault, so the possibility of such interception is greatly reduced.

Only the north end of the Indian Creek drainage, upstream of the Genwal flume, is included in the CIA. The drainage continues south of the flume for roughly 8 miles. Indian Creek flows into Lowry Water, which then flows to Joes Valley Reservoir. The Crandall Canyon and Mill Fork leases occupy 3,100 acres in the upper end of this drainage.

BASELINE CONDITIONS

Surface-Water Quality And Quantity

In the Wasatch Plateau, water quality is good in headwater areas, where rocks contain only small amounts of readily soluble material; TDS concentrations are typically less than 500 mg/L, and dominant ions are calcium, magnesium and bicarbonate. TDS concentrations increase at lower elevations, where streams flow onto more saline marine sediments, especially the Mancos Shale, and sodium and sulfate ions become more common: diversion of low-TDS water for irrigation, return drainage of irrigation water from saline soils, and inflow of sewage and other pollutants add to the natural increase of dissolved solids in the lower elevation reaches of these streams. The lowest dissolved solids concentrations are associated with high flows from snowmelt, and highest concentrations with low-flows during late summer through winter. Sediment yields in the Upper Huntington Creek drainage were estimated at 0.1 acre-feet per square mile, and increasing to 3 acre-feet per square mile at lower elevations where rocks are predominantly shale and sandstone (Waddell and others 1981, pp. 17, 25-26, 28, Plate 6).

Ground-Water Quality And Quantity

Ground water occurs in all of the strata exposed in the Wasatch Plateau, but the units are not saturated uniformly. It is unlikely that large amounts of recharge infiltrate from the surface through the Star Point Sandstone, Blackhawk Formation and overlying units due to low permeability materials that impede downward migration of water. Ground water is found on several modes:

- Laterally discontinuous, perched, local water-bearing zones where permeable layers of sandstone overlie less permeable layers of shale, mudstone or clay;
- A more continuous saturated zone in the Star Point Sandstone;
- Alluvial materials in canyon bottoms; and
- Faults and fractures in the local strata.

According to Lines (1985), the Blackhawk Formation and Star Point Sandstone contain a regional ground-water system in the Trail Mountain area. In the East Mountain CIA, it does not appear that the Blackhawk contains large quantities of water. The Division adheres to the definition of "aquifer" as found in the Coal Mining Rules (R645-100-200); although there are local or perched aquifers in the Star Point and Blackhawk strata at East Mountain, the quality, quantity, use, storage, flow and transport, and discharge of ground water do not indicate a regional aquifer. Mine inflow is from channel-sandstones in the Blackhawk Formation that are exposed in the mine roof, discharges from the Star Point Sandstone through the floor, and in fault zones.

Precipitation occurs mainly as snow, augmented by intense thundershowers during late summer. Steep slopes drain excess water away quickly, so most water from snowmelt and thundershowers runs off rather than percolating into the ground. Thin soils with high clay content are rapidly saturated by runoff and reject additional infiltration from snowmelt and thundershowers. Only an estimated 3 percent (Danielson and Sylla, 1983) to 9 percent (Waddell and others, 1986) of the average annual precipitation goes to ground-water recharge, and most of this is retained in shallow, local, perched water-bearing zones. If threshold conditions involving the soil and the amount, rate, and timing of precipitation are not met, there can be years with precipitation but no recharge (Barnes and others 1994, French and others, 1996).

Recharge percolates into permeable soils and rock, flows vertically until it hits an impermeable layer, then flows laterally. Impermeable layers present in the local strata tend to impede downward flow, but fractures can locally enhance vertical flow. Some water does infiltrate to deeper strata, where it becomes, in effect, stored water.

Perched Water-Bearing Zones

Springs associated with perched water-bearing units generally exhibit their highest flow during or immediately after snowmelt and recede to a baseflow condition or cease flowing by late summer or fall. Such rapid response indicates that the springs are close to their recharge sources and the systems are local rather than regional. Flow from these perched systems is often associated with fractures.

These systems may not always be perched in the strict sense because they may be underlain or even enveloped by saturated low-permeability rock, but large contrasts in hydraulic conductivity effectively isolate them.

The water may be either confined or unconfined. At an exploratory hole in Dairy Canyon (SE¼SE¼SE¼ Sec 3, T. 17 S., R 6 E.) on Trail Mountain, water from the Blackhawk Formation flowed to the surface at 150 gpm from a depth of 129 feet, approximately 500 feet above the Star Point Sandstone (Davis and Doelling, 1977, p. 36).

Perched water-bearing zones and associated springs are typically located in the North Horn Formation, at the North Horn - Price River contact, or at the base of the Castlegate Sandstone. A cluster of springs at the head of Little Bear Canyon issue from the base of the Castlegate Sandstone or are associated with landslides: these flow from 0.25 to 2 gpm. Numerous springs on the west flank of East Mountain issue from the Price River Formation and Castlegate Sandstone. Flows range from seepage to 10 gpm and are typically in the 1-2 gpm range.

In the coalmines, perched or isolated sandstone channels are routinely exposed in mine roofs or breached while installing roof bolts. Inflow can be significant initially but decreases, usually rapidly, as the system is drained, with no source of recharge sufficient to maintain the flow.

Ground Water in the Star Point Sandstone

Values of hydraulic conductivity in the Star Point Sandstone, measured at a number of locations and using different methods, range from 2.7 x10^{-2} cm/sec to 5.3 x10^{-6} cm/sec (Table 3). In general the Star Point is not a good aquifer and exhibits aquifer characteristics only locally, usually where weathering or fracturing have produced secondary permeability. Age dating of ground water from wells completed in the Star Point Sandstone from inside the Crandall Canyon Mine indicates a mean residence time of about 15,000 years (Mayo and Associates, 1999), which supports the concept that flow rates through the sandstone are very slow. The exact recharge mechanism for the Star Point sandstone is not known but it is more likely that recharge reaches the sandstones mainly through faults and fractures rather than by infiltration at outcrops or through overlying strata.

Water levels in monitoring wells in the Crandall Canyon No. 1 Mine workings and in the southernmost portion of the Crandall Canyon tract indicate a local east-southeast flow direction in the Spring Canyon Member. Local geologic structures, such as the South Crandall Syncline or the Flat Canyon Anticline, likely influence any ground-water flow through the Star Point, assuming flow generally follows the dip of the strata (EA, p. III-10).

Artesian conditions in the Star Point Sandstone have been confirmed at several locations. Well MW-1, located near the portals of the Crandall Canyon No. 1 Mine, was completed in the Spring Canyon Member of the Star Point Sandstone in March and April 1987. Water flowed at a rate of 175 gpm from apparently unfractured Star Point Sandstone from a zone noted by the driller as being coarser-grained than the rest of the unit (Crandall Canyon Mine MRP, p. 7-8). Genwal reported flow of 3.2 gpm in April 1987. For a number of years MW-1 supplied less than 1 gpm for use in the mine and bathhouse, but flow declined over time and there has been no flow since December 2002. (Tritium and radiogenic carbon values have not been reported for this water.) MW-7, another Crandall Canyon in-mine well, flowed 0.05 to 0.6 gpm (average 0.16 gpm) from June 1997 until the well became inaccessible in the last quarter of 2002.

In places, the Hiawatha Seam rests directly on the Spring Canyon Member of the Star Point Sandstone; otherwise there is an intervening shale layer of varying thickness. Unfractured coal and fine-grained sediments under the coal seam are an effective aquiclude. Unless they are fractured, under-coal rocks continue to confine the water after the coal is removed. In 1997, operations in the Trail Mountain Mine were in the down-plunge end of the Straight Canyon Syncline, where the Hiawatha Seam was directly on the Star Point Sandstone. Water flowed through the floor of the Trail Mountain Mine at 200 to 300 gpm until the Star Point was depressurized.

Alluvial Water-bearing Zones

Springs and seeps in the Indian Creek drainage occur in both the wedge of colluvial and alluvial sediments that were shed from East Mountain and in the exposed North Horn Formation. They are major factors in maintaining perennial flow in Indian Creek. Flows measured in these springs range from 0.5 to 50 gpm, with most springs flowing approximately 1 to 2 gpm (EA, 1997, p. III-9).

Alluvial water-bearing zones are associated with two important sources of culinary water. The waters are of high quality, requiring only chlorination before use.

North Emery Water Users Special Service District (NEWUSSD) has developed springs and collection galleries in the alluvial materials in lower Rilda Canyon. Springs higher in the basin contribute flow to the creek and likely support the shallow ground-water flow in the alluvial deposits. Studies performed by PacifiCorp indicate that approximately 80 percent of the recharge to the NEWUSSD springs originates in the Right Fork of Rilda Canyon.

Similarly, springs in upper Mill Fork Canyon contribute to ground water in the alluvium in the lower canyon, which produces flow in the lower canyon. This alluvial flow appears to be a major source of recharge to Little Bear Spring by way of the Mill Fork Fault Graben, so it is an important, although indirect, source of water for the CVSSD.

Faults

The hydraulic function of faults in the CIA is not well defined. Faults in this area, as elsewhere on the Wasatch Plateau, are generally thought to act as barriers to ground-water flow across the faults but as conduits for flow, horizontal and vertical, through fractures that parallel the faults.

The northeast-southwest trending Mill Fork Fault Graben branches from the Roans Canyon Fault Graben at Trail Mountain and extends to Huntington Canyon. Little Bear Spring flows from the fault on the northwest side of the graben. At least some of the recharge to Little Bear Spring flows from Mill Fork through this graben (Mayo, 2001c), as much as 60 to 70 percent by some estimates (WTR, 1998).

In the Huntington #4 Mine, mining in the Blind Canyon Seam across and within the Mill Fork Graben encountered only minor quantities of groundwater (Deer Creek Mine MRP, Volume 12, Hydrology p. 51). When the Roans Canyon Fault was intercepted by the Deer Creek Mine workings in the Blind Canyon Seam, it initially yielded water at up to 5,000 gpm, but flow eventually dropped to 150 gpm or less (Deer Creek Mine MRP, Volume 12, Hydrology Appendix B, p. 74-76).

Synthetic faults associated with the Joes Valley Fault zone yielded water at a rate of 30 gpm when intercepted in the Crandall Canyon Mine in the Hiawatha Seam; flow subsequently reduced to approximately 10 gpm (EA, p. III-10). Isotopic dating of water samples collected near this fault indicated the water has a mean residence time of 2,000 years or more (Mayo and Associates 1999).

In the CIA, strata along the upthrown side of Joes Valley Fault dip to the west, very likely from drag-folding. Flow along the fault could be contributing to the system of springs that supports flow in Indian Creek (Hansen, Allen and Luce, 1997).

Little Bear Spring

Little Bear Spring is one of the largest springs in the Wasatch Plateau. It flows from a fracture in the Panther Member of the Star Point Sandstone on the west side of the Mill Fork Graben, at the contact with the Mancos Shale. The elevation of the spring is 7,650 feet, approximately 100 to 150 feet below the Hiawatha coal bed. Little Bear Spring is developed and maintained by CVSSD and provides 65 percent of the culinary water for the cities of Huntington, Cleveland and Elmo. Water in the spring is of good quality, requiring only chlorine treatment before it is suitable for consumptive use.

Little Bear spring flows continuously, with average monthly discharge ranging from 200 to 440 gpm. Flow varies seasonally, with a typical increase of 20 percent in response to spring runoff, although spring runoff in 1994 and 2002 did not produce a seasonal increase and flow decreased from the beginning to the end of the year. The lowest average monthly measured baseflow was 198 gpm in April 1995. Isotopic analyses to evaluate the age of the water indicate that the spring discharges modern water that is isotopically similar to water in both Crandall and Huntington Creeks (Mayo and Associates, 1997a). Chemical analyses show the water is very similar to surface water in both Little Bear and Huntington Creeks.

The hydraulic conductivity of the Star Point Sandstone is low, so movement of ground water through the sandstone is slow, and flow from the Star Point Sandstone into the fracture system of the graben is not generally considered to be the source of water discharging at Little Bear Spring. Assuming a 5,000 foot capture zone along the Mill Fork Graben, a total saturated thickness of 50 feet in the Star Point Sandstone, and lateral hydraulic conductivity of 5.0×10^{-6} cm/sec, the potential flow available for discharge at the spring would be only 18.4 gpm (EA, p. III-12); however, it's easy to see that the flow estimate is very sensitive to the assumed value of hydraulic conductivity, and based on slug tests and determinations from core samples, hydraulic conductivity values in the Star Point Sandstone vary through at least a one order-of-magnitude range (Table 3).

Several investigations - including isotope analyses (Mayo and Associates, 1997a and 1997d), geophysical studies (Sunrise Engineering, 2001a and 2001b; WTR, 1999), dye-tracer tests (Mayo and Associates, 2001c), and analyses of piezometric, chemical, and flow data - indicate that one, perhaps the main, recharge area for Little Bear Spring is upper Mill Fork Canyon. Precipitation runoff, snowmelt, and discharge from numerous springs collect in both the channel and alluvium of Mill Fork, and water is diverted to Little Bear Spring through the Mill Fork Graben. Studies conducted prior to 1998 have indicated that there is also a component of flow reaching the spring from the north and west.

Rilda Canyon - NEWUSSD Springs

NEWUSSD has developed the springs in Rilda Canyon as a culinary water supply. Based on investigations by PacifiCorp, approximately 80 percent of the discharge at the springs originates as snowmelt and precipitation runoff that percolates into the alluvium in the Right Fork of Rilda Canyon (PacifiCorp 2002 Annul Hydrologic Report). Additional water enters the alluvium from nearby faults. Above the Rilda springs the stream is ephemeral, losing water to the alluvium, and below the springs it is considered perennial (even though there has occasionaly been no measurable flow for brief periods). Estimated ground-water yield from the Rilda Canyon basin is on the order of 400 gpm during high flow (Hansen, Allen and Luce, 1997). Reported flow through the NEWUSSD system averaged 160 gpm from 1990-2002, and ranged from 40 gpm to 340 gpm (PacifiCorp 2002 Annual Hydrologic Report, Table 34). Water quality from the spring system is good, with major constituents being calcium, bicarbonate and magnesium. Isotope data show the water is recent or modern in age.

Ground Water Intercepted by Mining

Water intercepted in mines on the Wasatch Plateau typically comes from channel-sandstones that are exposed in the mine roof as mining progresses. When mining is in areas where the roof is of finer-grained rock, inflows are much lower than where the roof is sandstone (1987 Cottonwood/Wilberg Mine Annual Report; 2001 PacifiCorp Annual Report). These sandstones typically drain for a few weeks, but flows decline rapidly and eventually cease, which indicates sources very limited in size and without extensive interconnection. Water also seeps or flows up through the floor from the Star Point Sandstone and from fractures or faults. Available information indicates that most of the water intercepted in mines is not in direct communication with the surface or near-surface ground water.

In 1996, water was sampled where the Deer Creek Mine crosses the Roans Canyon Graben. Isotopic analyses indicated this was modern water; however, these samples were taken after water had flowed from the fault for seven years: water that flowed from the fault when it was breached in 1989 might have been older water stored in the fault zone. Water temperatures in 1996 were 4 degrees cooler than other ground waters in the Deer Creek Mine, indicating a source closer to the surface. Fractured rocks in the fault were iron-stained, indicating oxygen from communication with the atmosphere. These all indicate that, at the time the samples were collected, the water entering the mine at the Roans Canyon fault crossing in the Deer Creek Mine was in recent connection with the surface, probably infiltrating through the nearby highly-fractured cliff faces. Mayo and Associates (1997b) collected a sample of gob-water that included water from where the 1st and 2nd Right entries intercepted the fault in 1990, a location more remote from the fractured outcrops. Isotopic analysis of this gob-water indicated water in the fault at locations more distant from the outcrop is older water and likely is not in communication with recent or shallow ground water (Mayo and Associates, 1997b).

Water intercepted as the Crandall Canyon No. 1 Mine approached Joes Valley Fault was a mixture of old and modern water. There was a minor tritium content in one of three samples, but ^{14}C indicated a mean residence time of 2,500 to 5,000 years (Mill Fork Extension MRP, Appendix B). There is apparently some modern water infiltrating from the surface through synthetic fractures associated with Joes Valley Fault and mixing with older water stored in the fractures. Isotopic analyses taken from water coming from the Crandall Canyon mine roof showed the water has a mean residence time of over 14,000 years (Mayo and Associates, 1997a).

IV. IDENTIFY HYDROLOGIC CONCERNS

SUBSIDENCE

Subsidence impacts are largely related to extension and expansion of existing fracture systems and upward propagation of new fractures. Inasmuch as vertical and lateral migration of water appears to be partially controlled by fracture conduits, readjustment or realignment in the conduit system will inevitably produce changes in the configuration of ground-water flow. Potential changes include increased flow rates along fractures that have "opened", and diverting flow along new fractures or within permeable lithologies. Increased flow rates along fractures would reduce ground-water residence time and potentially improve water quality. Subsurface flow diversion may cause the depletion of water in certain localized aquifers and potential loss of flow to springs that will be undermined.

Subsidence due to mining in the Blind Canyon and Hiawatha Seams is expected to be similar to that which has been experienced at other mines in the East Mountain area. Mining in the area has been by both room-and-pillar and longwall methods, and both will be used in future mining. Surface cracks are common above mines on East Mountain, especially along faults and in shallow overburden areas. Subsidence is likely only over longwall panels, over room-and-pillar areas where second mining is done, and in surrounding areas within the expected angle-of-draw.

The predicted angle-of-draw is 15 degrees for most areas, which is based largely on the experience of coalmine operators at East Mountain. Because of the possibility of subsidence fractures propagating to the surface along existing fault fractures, the USFS feels the greatest potential for opening of subsidence-caused cracks would be along Joes Valley Fault; therefore, the USFS has stipulated a 22 degree angle-of-draw adjacent to Joes Valley Fault. Based on angle-of-draw calculations, there will be some subsidence outside the Mill Fork Tract permit area, along the common boundary with the Crandall Canyon No. 1 Mine; however, based on PacifiCorp’s experience, subsidence will remain inside the permit boundary (Mill Fork Extension MRP, p. 5-37).

Within the Crandall Canyon No. 1 Mine permit area, subsidence from mining in the Hiawatha Seam has been less than anticipated. Layout of the mine has not allowed longwall-mining of large blocks (2000 Crandall Canyon Mine Annual Report), and therefore critical width (at which maximum subsidence occurs) has not been reached. Also, an overlying, competent 30-foot thick sandstone limits rubbelization and subsidence by acting as a structural beam that bridges the voids left by mining.

Because of USFS concerns on the effects of subsidence to Little Bear Creek and its associated ecosystem within the South Crandall Canyon Lease, a lease stipulation was added to prevent subsidence in the Little Bear Canyon area with overburden less than 600 feet unless it can be demonstrated that the effects of subsidence would be negligable (Special Coal Lease Stipulation #9). Although Little Bear Creek is intermittent within the South Crandall Lease area, the USFS considers the creek to be 'perennially functioning'. The ecosystem associated with Little Bear Creek is also reliant on the many springs emanating from the Blackhawk Formation and the base of the Castlegate Sandstone. Little Bear Creek is not projected to be undermined, but, in order to comply with the lease stipulation and conduct single-seam mining in Little Bear Canyon, Genwal has committed to: 1) additional monitoring of springs in Little Bear Canyon, 2) compiling a map identifying and showing the general location of vegetation in the area that could potentially be affected by mining, and 3) compiling a detailed map of riparian and wetland vegetation associated with the monitored springs. In the event of multiple-seam mining beyond spring site LB-7 in Little Bear Canyon, Genwal has committed to submitting a monitoring plan to be approved by the Division in concurrence with the USFS.

Because of USFS concerns on the effects of subsidence to Shingle Creek and springs within the addition to Lease U-68082, a lease stipulation was added to prevent full extraction mining with overburden less than 50 times the thickness of coal removed plus 50 feet (projected to be 300 feet in the lease modification area) (Special Coal Lease Stipulation #1).

In the Mill Fork tract, the plan is to mine adjacent long-wall panels, which should result in critical width and maximum subsidence similar to that at other PacifiCorp mines at East and Trail Mountains. Mining in the Mill Fork tract has been planned so that subsidence will occur as a general lowering of the surface over broad areas, which will limit change or damage to the land surface, land uses, and renewable resources. Based on PacifiCorp's experience, the surface will stabilize in most areas after two years. Based on a total combined thickness 20 feet of coal removed, maximum predicted subsidence for the Mill Fork tract is 75 percent or 15 feet (Mill Fork Extension MRP R645-301-525, Mining Methods and Subsidence). Actual subsidence is anticipated to be less than the predicted maximum because of the sandstone layers above the coal. Subsidence of the ground surface over other PacifiCorp operations on East Mountain has typically been at or below the predicted amount, although in one area it exceeded the predicted displacement by 84 percent (2001 PacifiCorp Annual Report, p. 131).

Tension cracks occur along the edges of full-extraction areas under shallow overburden on canyon slopes. The Castlegate Sandstone yields to subsidence by fracturing, so fracturing and spalling from tension cracks occur at Castlegate outcrops. Where overburden is thick, the clay-rich strata yield by plastic deformation, reducing the impacts of subsidence at the surface for most of the area (2001 PacifiCorp Annual Report, p. 134). With the exception of cracks in the Castlegate Sandstone, cracks are expected to heal naturally over a period of 2 to 5 years (EA, 1997, p. IV-2). Only limited and isolated surface cracks are reasonably foreseeable in other areas. The Division studied subsidence effects on East Mountain in 2003 and 2004. Surface fractures caused by subsidence were found in several areas, but no permanent damage to the surface or land uses were indicated.

GROUND WATER

The greatest mining-related potential for impacting ground-water resources in the CIA comes from dewatering and subsidence. Following spring and seep surveys and baseline studies prior to mine permitting, representative springs and seeps are chosen for a mine's monitoring plan to aid in the determination of mining-related impacts to the hydrologic balance and water rights.

Under the currently proposed mine layout for the Mill Fork Tract, mining will occur beneath numerous seeps and springs. Seventeen springs are being monitored within the Mill Fork Tract area, and another six in the adjacent area. (Mill Fork Tract MRP, Drawing MFS1830D). In addition to the 200 to 400 gpm flowing from Little Bear Spring, the other sixteen springs had a combined average flow of 40 gpm during the 2001 - 2002 baseline period, the largest average being 20 gpm from MF-213. Overburden thickness averages more than 1,000 feet beneath areas where springs are located. Diversion of spring flow is considered to be at overall low risk.

Twenty-five springs and seeps are being monitored within and adjacent to the Crandall Canyon Mine permit area (including seven within the South Crandall Lease tract). Monitoring of springs for the Crandall Canyon Mine has not identified any mining-related impacts and future diversion of spring flow is considered to be at overall low risk. Because of the importance of Little Bear Spring as a municipal water supply, the mine has committed to mitigate for potential disruption to the spring as a stipulation of the South Crandall Lease Agreement (Special Coal Lease Stipulation #17). A water treatment plant is to be constructed under the provisions of an agreement between Genwal, Pacificorp, and the CVSSD to assure an uninterrupted supply of culinary water equivalent to historical flows from the spring. The supply of culinary water will be assured irrespective of whether mining can be conclusively shown to have affected Little Bear Spring.

Changes in vegetation will have minimal impact on ground-water recharge because mining will disturb less than 150 acres of the 44,000-acre CIA. Probability of disturbance of phreatophytic vegetation, primarily cottonwood and some willow, is negligible.

The Cottonwood/Wilberg Mine Waste Rock Storage area is located below the coal resource on Quaternary sediment gravel that directly overlies the Masuk member of the Mancos Shale. Inasmuch as the Mancos Shale is considered a regional aquiclude, the storage facility presents a low risk for impacting ground-water resources.

Intercepted ground water is used in the mine underground, disposed of underground in sumps, or discharged to the surface. There are no developed wells in the Mill Fork or South Crandall Canyon tracts that use ground water from the area. Ground water encountered in the Crandall Canyon mine has been determined to have mean residence times of 2,500 years to over

14,000 years. Except for the modern water at TW-10, water intercepted in the PacifiCorp mines has mean residence times of 1,000 to 12,000 years.

Water users have expressed concerns that water intercepted underground may be discharged into a watershed other than the one where the ground water was originally destined. According to the Utah Coal Mining and Reclamation Act and rules, a mine may divert water underground and discharge to the surface if material damage to the hydrologic balance outside of a permit area is prevented and disturbance to the hydrologic balance within the permit area is minimized (R645-301-731.214.1). Furthermore, any state-appropriated water affected by contamination, diminution, or interruption resulting from underground mining must be replaced (R645-301-731.530). The Division evaluates a mine's Probable Hydrologic Consequences Determination (PHC) and updates the CHIA prior to permitting, and reviews water monitoring data during mining and post-mining reclamation to determine if adverse hydrologic impacts, as defined by the rules, can be demonstrated. Underground mining may result in some diversions of intercepted ground water into drainages that are not topographically within (above) the area where the water was encountered. The PHCs of mines in the East Mountain CIA have demonstrated that water that is projected to be intercepted is mostly ancient and therefore hydrologically isolated from springs, seeps, and streams. If it is subsequently demonstrated that the mining has caused or will cause a diminution, contamination, or interruption of an appropriated water right or a material impact to the hydrologic balance either within or outside of the permit area, the permittee will be required by the division to address means of minimizing the impact and replacing any appropriated water rights.

Dewatering

Plate 2 delineates the CIA for current and projected mining in the East Mountain area. The CIA encompasses approximately 70,000 acres (109 miles^2) centered around East Mountain. The area within the CIA that is above the base of the Blackhawk Formation is approximately 44,000 acres (69 miles^2), the approximate area covered by coal leases is 33,000 acres (52 miles^2). Mine workings have or will undermine roughly half of the leased areas.

Baseflow discharge occurs directly to perennial streams where channels intersect ground water within the Blackhawk Formation and Star Point Sandstone. Horse, Blind, Crandall, Little Bear, Mill Fork, Rilda, Deer, Cottonwood, Huntington, and Indian Creeks are the perennial streams in the CIA. All of these streams except Indian Creek intersect the lower Blackhawk Formation and Star Point Sandstone. A study conducted along Miller Creek in the adjacent Gentry Mountain area indicated streamflow substantially increases (from 8 to 115 gpm) as a result of baseflow discharge from the Blackhawk Formation and Star Point Sandstone (Cyprus-Plateau Mining Company, Star Point Mine PAP, pages 783-40). The results from the Miller Creek Study suggest perennial steams that traverse the Blackhawk Formation and Star Point Sandstone on East Mountain receive similar base-flow recharge; accordingly, total base-flow recharge to the nine perennial streams that cross the Blackhawk Formation and Star Point

Sandstone in the CIA can be roughly estimated to be on the order of 100 to1,000 gpm.

Based on UPDES discharge data reported for 2004 and information provided in annual reports and MRPs, the estimated volume of water that coal-mining operations within the CIA are withdrawing from the ground-water system, including coal extraction and evaporation from mine ventilation, is approximately 1,488 gpm (2,400 acft/year)..

Table 13
Estimated Ground-Water Discharge
East Mountain CIA

Discharge	Rate (gpm)	2004 Yearly Total	
		(gallons)	(acre-feet/yr)
Baseflow to Perennial Streams*	550	289.1×10^6	887
Crandall Canyon, Deer Creek, and Cottonwood/Wilberg Mines	1,488	782.1×10^6	2,400
Total	**2,038**	**$1,071 \times 10^6$**	**3,287**

* Average based on the estimated 100 to 1,000 gpm

Approximately 44,000 acres within the CIA are a potential recharge area for the strata above the coal seams (Plate 5). Using 20 inches as the average annual precipitation over this potential recharge area, the estimated total annual precipitation over the outcropping recharge area is 73,000 acre-feet.

Table 14 compares the number of springs from rock units overlying the coal seams with area of outcrop and estimated precipitation. Values for Total Precipitation on Outcrop are skewed because 20-inches of precipitation/year was used for all strata: the amount of precipitation is not strictly related to elevation, but this estimate of Precipitation on Outcrop is probably low for the Flagstaff and North Horn formations at the highest elevations and high for the Blackhawk Formation at lower elevations. Along with greater precipitation at higher elevations, the large surface area of Flagstaff and North Horn that is exposed for recharge is undoubtedly an important factor as to why the number of springs and amount of discharge are so much greater in the Flagstaff and North Horn formations than in lower strata.

Springs that issue from the Star Point Sandstone (most notably Little Bear Spring that flows from the lower Star Point Sandstone but is not recharged from adjacent strata) and those that issue from alluvium are not accounted for in Table 14 because they discharge below the Blackhawk Formation. Little Bear Spring discharges 200 to 400 gpm, and average flow measured by CVSSD has been approximately 340 gpm. Of the 120 identified alluvial springs, the 8 that are monitored yield 190 gpm.

Table 14 Precipitation and Springs for Areas Above the Blackhawk Coal Seams East Mountain CIA					
Lithologic Unit	Outcrop Area (acres)	Total Precipitation on Outcrop * (acre-feet)	Seeps and Springs Identified	Seeps and Springs Monitored	Total Average Measured Discharge
Undivided - Flagstaff Limestone, North Horn Fm.	17,600	29,000	260	108	2,655 gpm
Price River Fm.	9,400	16,000	127	34	109 gpm
Castlegate Sandstone	5,000	8,000	32	6	6 gpm
Blackhawk Formation	12,000	20,000	83	17	110 gpm
Totals	**44,000**	**73,000**	**502**	**157**	**~2,900 gpm**

* based on 20-inches/year

Flows have been measured at only about one-third of the known seeps and springs; however, monitored springs are those with the greatest and most consistent flow, so the flow from the unmeasured springs and seeps is a fraction of measured flow. Using 50 percent of the measured flow as a very rough estimate of the flow at unmonitored seeps and springs, estimated ground-water discharge by seeps and springs in the CIA is on the order of 4,000 to 4,500 gpm.

Total ground-water discharge within the CIA is therefore estimated to be roughly 6,600 to 8,300 gpm (11,000 to 14,000 acre-feet/year), where 100 to 1,000 gpm represents baseflow to streams, 1,488 gpm results from mining activities, and 4,000 to 4,500 gpm is spring discharge.

Inflow to the Deer Creek Mine increased in the late 1980's as mining progressed northward (Figure 5). The increased flow into the mine was attributed partially to better record keeping, but also to the increasing amount of sandstone being exposed in the mine roof and to mining in the trough of the Straight Canyon Syncline and near the Roans Canyon Fault Graben.

To access coal reserves for the Deer Creek Mine, PacifiCorp drove a rock tunnel across the Roans Canyon Fault Graben in 1989 and 1990. Prior to advancing the tunnels, a drilling and testing program identified two water-bearing fracture zones within the graben (HIS, 1988). The mine operator minimized inflow during development of the rock tunnels by dewatering the zone prior to development and by pressure-grouting the water-bearing zones during development. Predicted potential inflow to the tunnels was as much as 500 gpm (HIS, 1988). There is no record on what the actual inflow was from the tunnel construction, but mine discharge increased significantly during construction of the tunnels (Figure 5) (Mayo and Associates, 1997b; 1990 PacifiCorp Annual Report). When work was completed, inflow to the tunnels was 50 gpm (1990 PacifiCorp Annual Report).

Also in 1990, mining operations unexpectedly breached the Roans Canyon Fault Graben at two locations in the 4th North section. The first penetration was in January 1990 in the 1st Right entries, where several hundred gallons per minute entered through the mine roof. The next breach was in April when the 2nd Right entries intercepted a small sympathetic fault: the mine operator estimated peak discharge to be as much as 5,000 gpm initially, but flow had declined to 125 gpm by March 1991 (Mayo and Associates, 1997b; 1990 PacifiCorp Annual Report).

Mining in the Mill Fork Extension and South Crandall Canyon Tract will not cross any major structures such as the Roans Canyon Fault, so the only expected inflows are drippers from channel-sandstones in the roof. These flows may increase when operations reach the trough of the Crandall Canyon Syncline. Planned mining operations should remain far enough from the Joes Valley Fault zone that there will be no significant increase in flows from that fracture zone.

Following the cessation of mining, the discharge of ground water to streams, the Huntington Power Plant and the atmosphere, will cease and workings will flood. Complete flooding of the abandoned mine workings will probably never occur because hydraulic head will increase as the mines flood until it reaches equilibrium with water within the surrounding rock. The potentiometric surface is below the coal throughout most areas that have been or will be mined. Mine flooding will conceivably recharge storage and re-establish the natural ground-water conduit system that was operational prior to mining, and restore stream baseflow that might have been lost.

SURFACE WATER

Increased discharge, especially runoff from disturbed areas, could alter flow volumes, water quality, and runoff and flood patterns in creeks. Mining in the Mill Fork Extension and South Crandall Canyon Tract is not expected to increase discharge of surface or ground water beyond current levels. Creeks and drainage areas discussed are shown on Plate 4, Surface Water Drainage Map.

Subsidence could affect the character of drainages by altering the natural slope of the channel. However, large-scale impacts are unlikely because of the thick overburden (typically projected to be from 600 to 2,600 feet thick) between the mine operations and the surface drainages. In addition, full extraction mining is not planned under any perennial reaches of streams within the CIA. Where undermining beneath a drainage, the thinnest overburden (600 feet) is projected to be in the Right Fork of Mill Fork Canyon above the 8th North Mains in the Blind Canyon Seam. Where full extraction of both seams is planned under this drainage, overburden thickness will be 800 feet for a small area but rapidly thickens upstream because of the steep gradient of the stream channel. Minimum overburden thickness in Rilda Canyon is 1,200 feet, above the access tunnels; the minimum over longwall panels will be 1,800 to 2,000, and 2,200 feet over areas where both seams are mined. Only a small area of the Left Fork of Crandall Canyon will be involved in full-extraction mining, where minimum thickness is projected to be 800 to 1,000 feet. At the Skyline Mine, mining under perennial drainages has been monitored: where there was 600 feet or more of overburden, single-seam longwall mining has not produced permanent adverse effects at the surface (Sidle, 1995). Surface cracks are possible above subsided areas but, because of thick overburden in the CIA, conductivity between surface cracks and the rubbelized zone is not likely.

The potential for cracks to divert water underground is limited by the self-healing characteristics of the formations, which consist of interbedded claystone, siltstone, and sandstone that are rich in montmorillonite clays. Fractures at the surface are prone to heal rapidly because of the expanding nature of these clays. Material from the Blackhawk Formation was examined by X-ray diffraction and found to contain up to 58 percent montmorillonite clays (Crandall Canyon Mine MRP, App. 7-41). These clays absorb water and their volume can expand as much as 50 percent even when they are associated with other soil and rock materials.

Cottonwood/Wilberg Mine

The Cottonwood/Wilberg Mine is located in Grimes Wash. Flow from the Right Fork of Grimes Wash originates in interbedded shales, siltstones, and sandstones of the North Horn Formation, which contain an abundance of calcareous material. As a result, the Right Fork contributes a relatively high amount of suspended solids to the Grimes Wash drainage.

As reported in 1985, the TDS level increased slightly at the location below the mine. Two possible factors stated for the rise were Cottonwood/Wilberg Mine discharge and Mancos Shale seeps. Due to the fact that no water was discharged from the mine during 1985 through 1988 (one exception in August 1986), seeps emanating from the Mancos Shale probably have the greatest influence upon the level. Periodic sampling during 1986 and early 1987 confirmed the seeps' contribution to the TDS level. The average for the four samples collected was 1,188 mg/1, representing a nearly 3.3 fold increase over the historical averages for the Right and Left Forks (Annual Hydrologic Monitoring Report for 1988, pg. 24).

All surface facilities are treated by sediment controls and as such, potential impacts from sediments generated from disturbed areas are minimized.

<u>Waste Rock Disposal Site</u>

Waste rock generated from the Des-Bee-Dove and Cottonwood/Wilberg Coal Mines is disposed of in a series of seven interconnected storage cells at a waste rock disposal site (Plate

3). The waste rock storage site is at an elevation of 6,800 feet. Annual precipitation is approximately 14 inches, and the vegetation surrounding the waste rock storage area is the pinyon-juniper community type.

Each complete waste rock containment structure consists of over four feet of shot and crushed coal, sandstone, and mudstone rock. The anticipated waste rock was approximately 70 percent sandstone, 20 percent interbedded mudstone and siltstone, and 10 percent bony coal. Roof and floor materials are sandy loam to loamy sand in nature. Analyses of roof and floor material indicate high Sodium Adsorption Ratios (SAR) (Mean = 17.36, Standard Deviation = 25.14), and movement of sodic materials is typically associated with hydroscopic rise and leaching processes. High SAR in the waste rock storage area should not be a concern to water quality because drainage from the storage site should be minor.

Analyses from Drill Hole EM-23C, indicates low pH (3.3, 2.9, 3.7) within the mudstones and siltstones directly below the Hiawatha Coal Seam. Analyses of roof and floor samples indicate that Fe_2 in pyrite and marcasite averages 8.15% (Standard Deviation = 10.82%). However, the colluvium and Mancos Shale that underlie the waste rock storage area are calcareous and should be sufficient to neutralize any acidic seepage from within the waste rock storage site.

Most water associated with the Cottonwood/Wilberg Waste Rock Storage Area will evaporate, but some will inevitably percolate through the storage cells and underlying colluvium deposits. Drainage from the waste rock storage site should have little down-gradient effect: it will eventually contact the Mancos Shale, where waters have naturally high TDS, mainly sodium, chloride, and sulfate ions.

Deer Creek Mine

Referencing Table 15, it is apparent that the quality of Deer Creek runoff degrades from the upper to lower sampling points. The quality of the lower point is dominated by chloride, sulfate and sodium. In addition to the mine and sedimentation pond discharges, quality is affected by the Mancos Shale at the lower end of the mine site.

Table 15
Deer Creek Water Quality
(1984 – 2002)

		Conductivity (umhos/cm)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	Sodium (mg/L)	Sulfate (mg/L)	Magnesium (mg/L)	TSS (mg/L)
Above Mine (DCR01)	Max	1,140	897	53	176	45	255	33	162
	Mean	566	342	44	17	34	61	28	21
Mine Discharge (UPDES 002)	Max	1,380	3,300	150	1,460	150	520	90	2,780
	Mean	850	630	90	40	30	200	50	70
At Permit Boundary (DCR04)	Max	7,000	2.340	96	1,093	728	560	56	547
	Mean	1,059	590	66	85	113	146	42	31

Surface water originating from undisturbed lands upstream of the facilities area is controlled and diverted around the operation. Surface drainage facilities are designed to safely control water and sediment runoff from all disturbed areas. Storm runoff from 25 acres of disturbed land within the mine facilities area is collected in a system of open ditches, bermed roadways and culverts, then temporarily detained in the Deer Creek Mine sedimentation pond and released to Deer Creek at UPDES discharge point UT0023604-001. The sedimentation pond is designed to detain the 10-year, 24-hour storm event. When the 10-year, 24-hour design event is exceeded, sediment detention times are reduced, leading to a slightly higher sediment load in Deer Creek. Surface-water impacts associated with the Deer Creek Mine operations have been minimal. The Deer Creek sedimentation pond discharge exceeded UPDES limits for TDS in May 1990 during an emergency discharge from the mine; otherwise it has been within limits.

Discharges from the Deer Creek Mine have been reported as early as 1978, and discharge has been almost continuous since 1980 (Figure 5). Discharge has averaged 1,400 gpm, and the maximum reported discharge was 3,700 gpm, in December 1990. The minimum was 6 gpm, in February 1995. Prior to December 1990, all discharge was piped to the Huntington Power Plant and none entered the natural drainages. A temporary discharge permit was issued in November 1990 because of high inflows into the mine at the Roans Fault crossing, and 1990 and 1991 was a period of consistently high discharge rates. Currently, the power plant is not accepting water from the mine (Dennis Oakley – Energy West, personal communication, January 7, 2003). Water is now diverted to abandoned mine sections and used underground for mine operations, and only excess water is discharged directly to Deer Creek at UPDES discharge point UT0023604-002: excess water from the Mill Fork Extension will also be discharged through this point.

Reclamation of the drainage at the Deer Creek Mine will consist of removing the temporary drainage system, diversion and sedimentation pond. Permanent channels will be constructed over the fill and into a splash basin. All channels are designed to pass the 100-year, 24-hour runoff peak flow. The proposed surface-water reclamation plan will have negligible impact on water quantity or quality of Deer Creek and its tributaries.

Des-Bee-Dove Mine

The Des-Bee-Dove Mine complex ceased operations in February 1987 for economic reasons. The mines were dry and water for mine operations was piped from springs higher on East Mountain.

Reclamation began in 1999, and Phase I reclamation is scheduled for completion in 2003. All surface drainage is treated by a sedimentation pond and released to an ephemeral wash. Because there are no active operations other than reclamation, and because all surface water is treated by a sedimentation pond, the effects of the Des-Bee-Dove Mine operations on the hydrologic balance are negligible.

Huntington #4 Mine

The old workings of the Huntington #4 Mine underlie approximately 1,300 acres in Mill Fork and Little Bear Canyons. There were 12 acres of surface disturbance in Mill Fork Canyon. The mine is reclaimed and bond has been released. There is no anticipated impact to Mill Creek from the Huntington #4 Mine due to the lack of potential sources.

Crandall Canyon Mine

The Crandall Canyon No. 1 Mine is located in Crandall Canyon. The U.S. Geological Survey established a gauging station at the mouth of Crandall Canyon in 1978. Flow data collected at the gauging station are not complete for the winter in most years, due presumably to the gauge or flume freezing. However, the limited data indicate that most of the flow of Crandall Canyon Creek occurs in the period of May through July. For the periods when flows were recorded, maximum flow was 39,000 gpm, the average was 2,400 gpm, and there were short periods when there was no flow. Assuming an average of 0.5 gpm for the period when records were missing, the average annual flow for the six-year period of data would be approximately 2,800 acre-feet.

Crandall Canyon Creek is diverted beneath the mine facility in Crandall Canyon through a culvert. Water monitoring is conducted in the creek at a flume above the facility and the culvert (upper flume – UPF) and approximately 500 feet downstream of the culvert at another flume (lower flume – LOF). Surface water quality data collected from Crandall Canyon Creek by Genwal since 1985 indicate that the dominant ions are calcium and bicarbonate. As shown in Table 16, the water quality of Crandall Canyon Creek degrades from the upper to lower monitoring point. The change in water quality is likely due to a combination of mine discharge and runoff through the Mancos Shale at the lower end of the mine site.

Table 16
Crandall Canyon Creek Water Quality
(1994 – 2004)

		Conductivity (umhos/cm)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	Sodium (mg/L)	Sulfate (mg/L)	Magnesium (mg/L)	TSS (mg/L)
Above Mine Facility (UPF)	Max	1,200	678	111	58	39	341	60	44
	Mean	571	337	68	3	5	63	38	6
Mine Discharge (UPDES 002)	Max	808	1,293	NS	NS	NS	NS	NS	14
	Mean	708	439	NS	NS	NS	NS	NS	6
Below Mine Facility (LOF)	Max	976	700	97	230	116	193	53	41
	Mean	670	413	63	17	30	90	39	9

NS = Not Sampled

Surface drainage facilities are designed to safely control water and sediment runoff from all disturbed areas. Storm runoff from disturbed land within the mine facilities area is collected in a system of open ditches, bermed roadways and culverts, then temporarily detained in the Crandall Canyon Mine sedimentation pond. The sedimentation pond is designed to detain the 10-year, 24-hour storm event. There has been only one reported discharge from the sediment pond UPDES discharge point UT0024368-001 (March 2000) to Crandall Canyon Creek between 1988 and 2005. This sediment pond discharge was within UPDES limits for all parameters.

Reclamation of the drainage at the Crandall Canyon Mine will consist of removing the temporary drainage system, diversion and sedimentation pond. The proposed surface-water reclamation plan will have negligible impact on water quantity or quality of Crandall Canyon Creek and its tributaries.

Mill Fork Extension

Headwaters of Rilda, Mill Fork, and Crandall Creeks are in the Mill Fork tract, but full extraction mining is not planned under the main channels of these streams (Mill Fork Extension MRP, p. 5-23). The lease impinges on the perennial reach of Crandall Canyon, but no mining is planned for this area.

The short, steep tributaries of Indian Creek that are on the west side of the tract could be influenced by surface subsidence. Cracks on the surface along the Joes Valley Fault trace might divert water from these tributaries, and such loss of water could reduce the flow that supports the streamflow and wetlands in Joes Valley. Under the proposed mine plan, active workings would extend within approximately 500 feet of Joes Valley Fault at the mine level; however, no full extraction mining is to be done in the areas nearest the fault, as determined by the 22 degree angle-of-draw stipulated by the USFS. Projections of subsidence effects indicate there should be no subsidence or tension cracking involving the Joes Valley Fault zone, so the potential for adverse impacts to the tributaries that cross this fault is very small.

AQUATIC HABITAT

Intermittent channels provide aquatic habitat when water is present, including spring spawning habitat for cutthroat trout and sculpins. The intermittent streams probably contribute invertebrates to Huntington Creek, an important sports fishery in the region. Aquatic habitat could be lost or degraded if the character or quantity of streams and streamflows change as a result of subsidence. Only intermittent headwaters will be undermined and subsided; no perennial reaches will be undermined or subsided by planned mine operations in the CIA.

Because flows in these small streams decrease in late summer and early fall, their primary use by fish will be as spawning and rearing streams. If present at all, adult fish are likely present in headwater areas only during the spring reproductive period.

Gravels suitable for spawning are patchy in lower-gradient reaches of the tributaries to Huntington Creek. Because successful spawning requires the presence of clean, well-oxygenated spawning gravels, the USFS considers it a high priority to protect these channels from excessive erosion and sedimentation (EA, 1997, p. III-16). Studies in Burnout Canyon (Sidel, 1995) are inconclusive but suggest that subsidence may cause fragmentation of riffles into cascades, so spawning habitat in low-gradient riffles could become inaccessible due to step-like fragmentation of the longitudinal profile of the stream: drops of twelve inches or more are considered barriers for inland trout species. It is conceivable that subsidence could shift the stream substrate enough to present barriers to the movement of spawning fish; however, none of the lower reaches of streams will be subsided in the Mill Fork CIA.

Crandall Creek has a year-round population of adult cutthroat trout. Prior to expansion of the Crandall Canyon No. 1 Mine pad, the fish were in the beaver ponds immediately adjacent to the mine portal. Expansion of the pad and culverting of the stream required mitigation to protect this population: the mitigation is described in Appendix 3-12 of the Crandall Canyon Mine MRP.

Water withdrawals within the Colorado River Basin impact habitats of four endangered fish species in the Colorado River and its tributaries: the Colorado squawfish, razorback sucker, bonytail chub, and humpback chub. Annual water withdrawals in excess of 75 acre-feet could trigger consultation requirements with the U.S. Fish and Wildlife Service (USFWS). The mines in the CIA discharge more water than they consume.

V. IDENTIFY RELEVANT STANDARDS AGAINST WHICH PREDICTED IMPACTS CAN BE COMPARED

The UPDES permits for the PacifiCorp and Genwal mines provide some standards for water quality in the area.

Utah water quality standards exist for numerous parameters other than those discussed below, but at this time there is no evidence to indicate nor reason to believe that those parameters are of concern in the East Mountain CIA. However, additional parameters recommended for routine monitoring in UDOGM directive Tech-004 are included in the water-monitoring plans of the PacifiCorp and Crandall Canyon Mine operations.

Flow: There is no standard for flow in the Utah water quality standards. The UPDES permits for the PacifiCorp and Crandall Canyon Mines contain no limit on flow. Discharge is to be measured monthly, and the duration of intermittent discharge is to be reported along with flow. Characteristics such as stream morphology, vertebrate and invertebrate populations, and water chemistry can be affected by changes in flow and therefore can provide an indirect standard for flow.

Oil and Grease: There is no State water quality standard for oil and grease, but the limit in the PacifiCorp and Crandall Canyon Mines UPDES permits is 10 mg/L, which is typical of UPDES permits for coalmines in the Wasatch Plateau and Book Cliffs. One grab-sample a month is required to measure oil and grease at the Crandall Canyon Mine. Oil and grease are not analyzed routinely at the PacifiCorp Mines, but any observation of visual sheen requires a sample be taken immediately.

A 10 mg/L oil and grease limit does not protect fish and benthic organisms from soluble oils such as those used in longwall hydraulic systems, and UDWR has recommended soluble oils be limited to 1 mg/L (Darrell H. Nish, Acting Director UDWR, letter dated April 17, 1989 to Dianne R. Nielsen, Director UDOGM).

pH: Allowable pH ranges are 6.5 to 9.0 under State water quality standards for all Classes, and also under the UPDES permits.

Total Dissolved Solids (TDS) concentrations: TDS is commonly used to indicate general water quality with respect to inorganic constituents. There is no state water quality standard for TDS for Classes 1, 2, and 3, but 1,200 mg/L is the limit for agricultural use (Class 4).

The Crandall Canyon Mine UPDES permit allows a daily maximum concentration of 723 mg/L TDS, to be determined by one grab sample per month. TDS allowances vary for the PacifiCorp mines:

Table 17
TDS Limits for PacifiCorp Mines

Mine	UPDES Site	Maximum Loading lbs/day	Quantity or Concentration Average	Quantity or Concentration Daily Max.
Des-Bee-Dove		2,000		Report Daily Max.
Deer Creek 001	001	2,000	Report 30-day Average	5,000 mg/L
	002		800 mg/L Quarter Average	1,000 mg/L
Trail Mountain 001	001	2,000		5,000 mg/L
	002			1,200 mg/L
Cottonwood/Wilberg	001	2,000		
	002, 003, and 005	2,000 (Combined)		
	004	2,000		

Total Suspended Solids (TSS) and Settleable Solids: the PacifiCorp and Crandall Canyon Mine UPDES permits have the following allowable limits on TSS: 30-day average, 25 mg/L; 7-day average, 35 mg/L; daily maximum, 70 mg/L. TSS is to be determined by a monthly grab sample.

There is no State water quality standard for solids in the water, but an increase in turbidity is limited to 10 NTU for Class 2A, 2B, 3A, and 3B waters and to 15 NTU for Class 3C and 3D waters.

Under the current UPDES permits, all samples collected during storm water discharge events are to be analyzed for settleable solids. Samples collected from increased discharge, overflow, or bypass that is the result of precipitation that does not exceed the 10-year, 24-hour precipitation event may comply with a settleable solids standard of 0.5 ml/L daily maximum rather than the TSS standard, although TSS and the other UPDES parameters are still to be determined. If the increased discharge, overflow, or bypass is the result of precipitation that exceeds the 10-year, 24-hour precipitation event, then neither the TSS nor settleable solids standard applies.

Iron and Manganese: UPDES limits on daily maximum total iron, determined by a monthly grab sample, are as follows:\

Crandall Canyon Mine	1.3 mg/L
Trail Mountain Mine	1.4 mg/L
Deer Creek Mine	1.0 mg/L
Cottonwood/Wilberg Mine	1.8 mg/L at 001 and 002
	1.0 mg/L at 003, 004, and 005
Des-Bee-Dove Mine	1.0 mg/L

State water quality standards (UDWQ 1994) allow a maximum of 1,000 µg/L (1 mg/L) dissolved iron in Class 3A, 3B, 3C, and 3D waters, with no standard for Class 1, 2, and 4 waters.

Monitoring of total manganese is required by SMCRA and the Utah Coal Mining rules, but there is no UPDES or Utah water quality standard for either total or dissolved manganese.

Macroinvertebrates: Macroinvertebrates are excellent indicators of stream quality and can be used to evaluate suitability of a stream to support fish and other aquatic life. Baseline studies of invertebrates (Lines and Plantz, 1981; USGS, 1980, 1981,and 1982; and Price and Plantz, 1987) provide standards against which actual conditions in Huntington, Crandall, and Cottonwood Creeks can be evaluated if desired.

Whole effluent testing - chronic toxicity: Requirements for biological testing with Ceriodaphnia and fathead minnows have been recently added to the UPDES permits for outfall 002 at the Crandall Canyon Mine and outfall 001at the Cottonwood/Wilberg Mine.

MATERIAL DAMAGE

Material damage to the hydrologic balance would possibly manifest itself as an economic loss to the current and potential water users, would result in quantifiable reduction of the capability of an area to support fish and wildlife communities, or would cause other quantifiable adverse change to the hydrologic balance outside the permit area. The basis for determining material damage may differ from site-to-site within the CIA according to specific site conditions. Surface-water and ground-water concerns have been identified for CHIA evaluation.

The Division received comments from NEWUSSD and Huntington-Cleveland Irrigation Company, plus from several individuals who receive water from these companies regarding permitting of the Mill Fork Extension. The main concern was that flows from streams and springs, in particular Little Bear Spring, would be diminished by mining operations in the Mill Fork Extension and the South Crandall Lease area. Water users have also expressed concern to the Division and the Office of Surface Mining that

The USFS excluded the area covered by the South Crandall Canyon Coal Lease Tract from the Mill Fork Lease because of concerns for potential adverse impacts to Little Bear Spring. The South Crandall Canyon area was reevaluated, and based on a Decision Notice/Finding of No Significant Impact (DN/FONSI) signed by the BLM and USFS in February 2003, the South Crandall Canyon Tract was leased through competitive bid to Andalex in 2003. The mine has committed to mitigate for potential disruption to the spring as a stipulation of the South Crandall Lease Agreement (Special Coal Lease Stipulation #17). A water treatment plant is to be constructed under the provisions of an agreement between Genwal, Pacificorp, and the CVSSD to assure an uninterrupted supply of culinary water equivalent to historical flows from the spring. The supply of culinary water will be assured irrespective of whether mining can be conclusively shown to have affected Little Bear Spring.

Parameters for surface-water quantity and quality

The potential material-damage concerns this CHIA focuses on are changes of surface flow rates and chemical composition that would physically affect the off-permit stream channel systems as they presently function and affect aquatic and wildlife communities. There is no farming in the CIA; however, there is livestock production. Therefore, water-quality and quantity criteria are intended to identify changes in the present discharge regime that might be indicators of economic loss to the water users and grazing-right owners, of significant alteration to the channel size or gradient, or of loss of capacity to support existing fish and wildlife communities within the CIA. In order to assess the potential for material-damage to these elements of the hydrologic system, the following indicator parameters were selected for evaluation at each evaluation site: low-flow discharge rate, TDS, and sediment load.

Low-Flow Discharge Rate

Measurements provided by mine operators are generally of instantaneous flow and provide some indication of long-term trends, but are probably no more accurate either individually or as a whole than the *poor* USGS measurements. In the Wasatch Plateau, Waddell and others (1981) found that correlating three years of low-flow records (September) at stream sites against corresponding records from long-term monitoring sites would allow the development of a relationship that could be used to estimate future low-flow volumes at the stream sites within a standard deviation of approximately 20 %. Ten years of measurements reduced the standard deviation to 16 - 17 % and 15 years of data reduced it to about 15 %. This relationship indicates that a change in low-flow rates of less than 15 to 20 % probably would not be detectable. A 20 % decrease in the low-flow rate will provide a threshold indicator that decreased flows are persisting and that an evaluation for material damage is needed. However, because flow in many streams is intermittent, material damage due to loss of flow is very unlikely, and the intermittent nature of the flow will also make any such loss almost impossible to detect. Any such apparent change in discharge would need to be correlated against precipitation and a drought index such as the PHDI.

Monitoring of mine-water discharge rates will provide a means to evaluate effects of the mine discharge on the receiving streams. The potential for material damage by mine discharge water is tied to the effect of that discharge on the flow in the receiving streams, and that effect will be most pronounced during low-flow. Water from disturbed areas will be monitored at the discharge from the sedimentation ponds.

Total Dissolved Solids (TDS)

The concentration of dissolved solids is commonly used to indicate general water quality with respect to inorganic constituents. Wildlife and livestock use is the designated post-mining land use for the CIA, so established dissolved solids tolerance levels for wildlife and livestock have been adopted as the thresholds beyond which material damage may occur. The state standard for TDS for irrigation of crops and stockwatering (Class 4) is 1,200 mg/L. If TDS concentrations persistently exceed 1,200 mg/L in springs, UPDES discharges, or receiving streams, it will be an indication that evaluation for potential material damage is needed.

Sediment Load

Sediment is a common constituent of ephemeral stream flow in the western United States. The quantity of sediment in the flows affects stream-channel stability and most uses of the water. Excessive sediment deposition is detrimental to existing aquatic and wildlife communities. Large concentrations of sediment in streamflow may preclude use of the water for irrigating crops because fine sediment tends to reduce infiltration rates in the irrigated fields, and the sediment reduces capacities of storage facilities and damages pumping equipment. Sediment load measurement error is, at a minimum, the same as the flow measurement error because sediment load is directly dependent on flow and in practice cannot be measured more accurately than the flow.

TSS is the indicator parameter initially chosen for evaluating the sediment hazard to stream-channel stability and irrigation. Threshold values have initially been set as the greater of 1 standard error above the baseline mean TSS value or 120 % of the baseline mean TSS value (by analogy with the low-flow discharge rate measurement accuracy and assuming that the error in TSS will contribute equally to the error in flow when determining mean sediment load). If TSS concentrations persistently exceed these threshold values it will be an indication that evaluation for material damage from sediment load in the streams might be needed.

Parameters for ground-water quantity and quality

The potential material-damage concerns this of CHIA are intended to limit changes in the quantity and chemical composition of water from ground-water sources to magnitudes that:

- Will not cause economic loss to existing or potential agricultural and livestock enterprises;
- Will not degrade domestic supplies;
- Would not cause structural damage to aquifers; and
- Will maintain adequate capacity for existing fish and wildlife communities.

To assess the potential for material damage to these elements of the ground-water hydrologic system, the following indicator parameters were selected for evaluation: seasonal flow from springs and TDS concentration in spring and mine-discharge water.

Ground-water concerns will be monitored at numerous springs, wells, and UPDES discharge points. Locations are identified on Plate 3. If UDOGM finds that inflow to the mine is significant or persistent, UDOGM can require monitoring of mine inflow.

Seasonal flow from springs

Maintain potentiometric heads that sustain average spring discharge rates, on a seasonal basis, equal or greater than 80 % of the mean seasonal baseline discharge, or in other words baseline minus 20 % probable measurement error. The 20 % measurement error is based on analogy with the accuracy of measuring low-flow surface discharge rates. A 20 % decrease in flows, determined on a seasonal basis, will indicate that decreased flows are probably persisting and that an evaluation for material damage is needed.

TDS concentration

The concentration of total dissolved solids is commonly used to indicate general water quality with respect to inorganic constituents. The quality of water from underground sources reflects the chemical composition of the rocks the water passes through. Ground-water quality may be degraded by intrusion of poorer quality water from wells or mines, by leakage from adjoining formations, or by recharge through disturbed materials. Wildlife and livestock use ground water discharging from seeps and springs, and those are the designated postmining users most likely to be impacted. There is no water quality standard for TDS for aquatic wildlife. The state standard for TDS for irrigation of crops and stockwatering (Class 4) is 1,200 mg/L. If TDS concentrations persistently exceed 1,200 mg/L it will be an indication that evaluation for material damage is needed.

VI. ESTIMATE PROBABLE FUTURE IMPACTS OF MINING ACTIVITY WITH RESPECT TO THE PARAMETERS IDENTIFIED IN V.

GROUND WATER

Dewatering and subsidence related to mining have the greatest potential for impacting ground-water resources in the CIA.

Dewatering

Underground mining removes the support to overlying rock, causing caving and fracturing of overlying strata. In areas where fracturing is extensive, subsidence induced caving and fracturing can create conduits that allow ground water to flow into the mine. Dewatering caused by fracturing may decrease ground-water storage. Ground water in storage is not a major recharge source to springs. Fracturing of overlying strata will only intercept some of the deep ground-water storage. These areas will eventually drain and dry up because most of the beds have low hydrologic conductivities. In the CIA, it is unlikely that fractures will reach shallower perched aquifers that supply springs because of the thickness of the overlying strata over most areas to be mined is well over 600 feet. Water discharged downstream from the mines is at times of better quality than natural spring flow or base flow.

Total ground-water storage above the Blackhawk coal seams in the Mill Fork Tract can be estimated by assuming an area of 5,544 acres and a large storage coefficient of 0.10. Over much of the Mill Fork Lease Tract, cover above the coal seams reaches 2,600, so 1,000 feet is a reasonable estimate of potentially saturated thickness. Using these estimates as input, total ground-water storage above possible Mill Fork Extension workings could be as much as 554,400 acre-feet.

Annual average ground-water recharge for the 52 miles^2 above the PacifiCorp and Crandall Canyon Mines permit areas and the South Crandall Canyon Coal Lease Tract is roughly estimated to be 5,000 acre-feet, using 9 percent as the average infiltration factor and 20 inches as the average precipitation. Because of hydrologic isolation between the Blackhawk Formation and the surface, neither an increase in recharge rates nor a decrease in discharge rates at the surface is a probable consequence of dewatering deeper strata. A notable or measurable increase in recharge is also unlikely because recharge is generally available only for a few months during spring snowmelt and for very brief periods during summer thundershowers. During these seasonal, relatively short events the soils reach saturation quickly and reject most available water.

The Blackhawk Formation is probably saturated in most areas (Waddell and others, 1986, p. 41) and the Mill Fork Extension might be expected to produce water at rates similar to those observed in the Crandall Canyon Mine and the other PacifiCorp Mines. Most water entering mines comes from ground water stored in the overlying strata after fracturing of the rock immediately above the mine. Due to the great amount of strata between the Mill Fork Extension and springs on the surface, the springs or their recharge sources are not expected to be affected. The mobility and expanding characteristics of clays, shales and mudstones in the overlying strata should also help seal conduits created by fracturing (Figure 6).

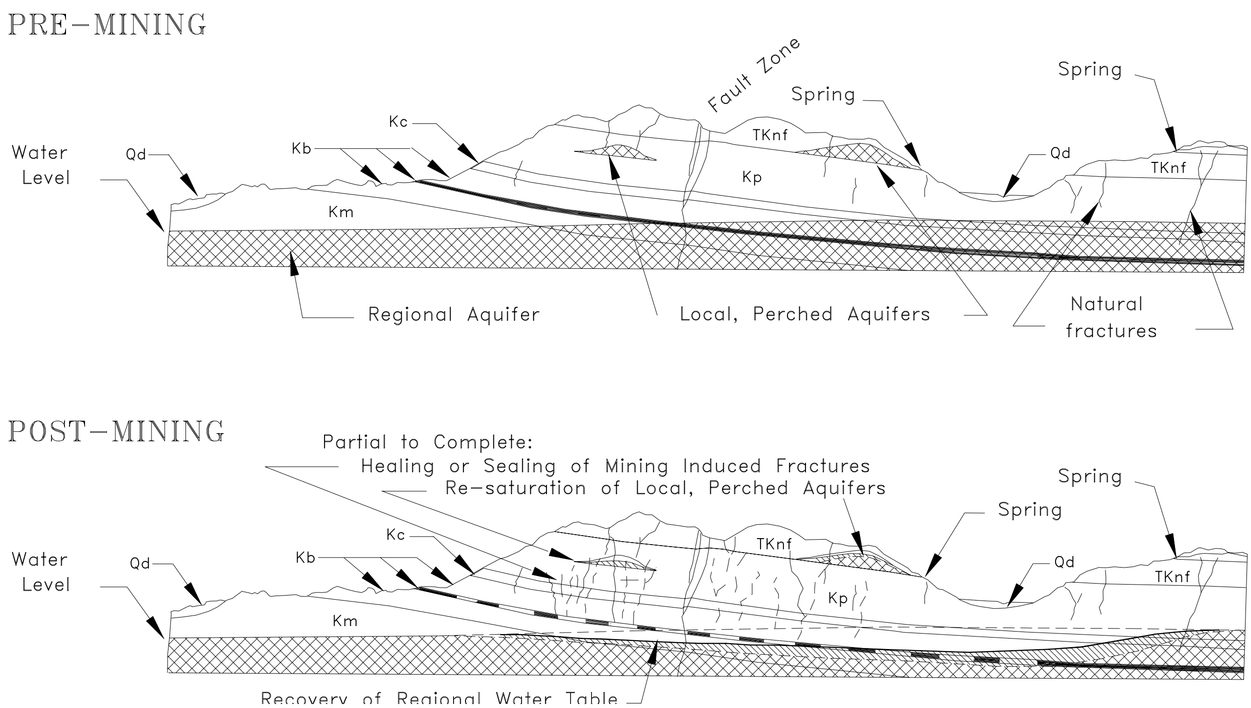

Figure 6. A diagrammatic cross-section of the Wasatch Plateau showing the relationship between mining, geologic strata and ground water before and after mining.

Subsidence

Subsidence impacts are largely related to extension and expansion of existing fracture systems and upward propagation of new fractures. Inasmuch as vertical and lateral migration of water appears to be partially controlled by fracture conduits, readjustment or realignment in the conduit system will inevitably produce changes in the configuration of ground-water flow.

Potential changes include decreased flow through existing fractures that close, increased flow rates along existing fractures that open further, and the diverting of ground-water flow along new fractures or within newly accessible permeable lithologies. Subsurface flow diversion may cause the depletion of water in local aquifers and loss of flow to springs that are undermined.

A 22-degree angle-of-draw along the west side of the Mill Fork Extension should be more than adequate to avoid interaction between mine-induced subsidence and the fractures of the Joes Valley Fault system.

The Castlegate Sandstone and thick overburden are responsible for minimizing surface subsidence over mines in the CIA. It is anticipated that similar thicknesses of the same formations over the Mill Fork Extension will also prevent subsidence. Annual reports for the PacifiCorp Mines indicate surface subsidence over current permit areas is as much as 75 percent of the thickness of the extracted coal. Under much of the Mill Fork Extension, mining will be done in two seams, with a combined thickness of up to 20 feet removed. Thickness of strata above the Mill Fork Extension ranges from 600 feet to 2,600 feet.

SURFACE WATER

Changes in flow volume and in water quality have the greatest potential for impacting water resources in the CIA. Sites that have been or are currently being used to monitor surface and ground water are shown on Plate 3.

Water Quality

Uncontrolled runoff from the disturbed lands and waste piles could increase sediment concentrations and alter the distribution and concentration of dissolved solids in the receiving streams. Sedimentation controls are already in place for receiving streams at the Crandall Canyon and PacifiCorp mines. There will be no additional surface disturbance with the Mill Fork Extension or the South Crandall Lease Tract.

Monitoring of ephemeral and perennial flows will continue in the major perennial and ephemeral drainages tributary to Huntington Creek. Indian Creek, a perennial tributary to Cottonwood Creek, will also continue to be monitored. Discharges directly from mines and from sedimentation ponds will be monitored when they occur.

If it becomes necessary to discharge water from the Mill Fork Extension or the South Crandall Lease Tract, the water will discharge into Deer Creek or Crandall Canyon Creek, respectively, at the existing UPDES discharge points and will be subject to monthly monitoring stipulated by a UPDES permit. In addition, Deer Creek and Crandall Creek are monitored above and below the mine discharge and the sedimentation pond, which controls sedimentation from the mine disturbed areas.

CIA Sediment Control

Sedimentation controls are already in place at the Crandall Canyon Mine and PacifiCorp mines. The Helco and Huntington #4 mines have been reclaimed and are no longer under reclamation bond. The Des-Bee-Dove mine is being reclaimed, but the sedimentation pond is still in place and the permitted area is bonded. Portions of the Cottonwood/Wilberg Mine and Deer Creek Mine permit areas have been reclaimed.

Water Quantity

If it becomes necessary to discharge water from the Mill Fork Extension or the South Crandall Lease Tract, the water will discharge into Deer Creek or Crandall Canyon Creek, respectively, at the existing UPDES discharge points and will be subject to monthly monitoring stipulated by a UPDES permit. In addition, flow volumes of Deer Creek and Crandall Creek are monitored above and below the mine discharge.

Upon termination of mining operations, discharge will be discontinued and the mines will begin to flood. There will be a reduction in surface flow because of the loss of the mine discharge. There is little or no baseflow to the intermittent streams, and surface flow will probably be unaffected by a return to pre-mining conditions as the mines flood. The time required for mine flooding will depend not only on the rate of water inflow but also on the amount of caving and the void space remaining after caving. Complete flooding of the mines may never occur because flow out of the mines through the roof, floor, and ribs and into the surrounding rock will increase as flooding increases the hydraulic head within the abandoned workings.

It is anticipated that discharge of water from the Mill Fork Extension mine operations will be similar what has been observed or predicted at the Deer Creek Mine. Upon termination of mining operations, workings will probably flood to some extent, but because the formations slope back away from the mine portals there will be no gravity discharge from the mine.

It is anticipated that no acid or toxic mineral contamination will take place during or anytime after mining. Soils and bedrock surrounding the coal contain buffering compounds of calcium carbonates and bicarbonates. All rock and coal waste having a potential of acid or toxic forming materials will be buried at least four feet deep at the waste rock disposal site. All disturbed area runoff will be contained, monitored, and treated if required before discharge to ensure water quality standards are met.

ALLUVIAL VALLEY FLOORS

There are no alluvial valley floors within the CIA

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VII. ASSESS PROBABLE MATERIAL DAMAGE

FIRST FIVE-YEAR PERMIT TERM

Deer Creek Mine

Planned operational monitoring will document any measurable changes in the surface- and ground-water systems. Surface disturbances and UPDES permitted discharges are not expected to degrade surface- or ground-water quality. There is no AVF to be impacted. Sediment control measures should continue to effectively prevent diminution of water quality in the receiving drainages.

<u>Mill Fork Extension</u>

The Mill Fork Extension is expected to have water inflow similar to that in the existing workings under East Mountain. Overburden thickness of 600 to 2,600 feet will minimize surface impacts of subsidence. No adverse impacts to streams or springs are anticipated from subsidence.

Crandall Canyon Mine

Planned operational monitoring will document any measurable changes in the surface- and ground-water systems. Surface disturbances and UPDES permitted discharges are not expected to degrade surface- or ground-water quality. There is no AVF to be impacted. Sediment control measures should continue to effectively prevent diminution of water quality in the receiving drainages.

<u>South Crandall Lease Area</u>

Mining in the South Crandall Lease area is projected to begin in 2005. There will be no new surface disturbance for mining in this tract. Water inflow is expected to be similar to that in the Crandall Canyon No. 1 Mine and any mine water discharge will be UPDES permitted. Significant springs to be undermined in Little Bear Canyon are in areas with greater than 600 feet of overburden and are subject to additional monitoring for potential effects of subsidence on the springs and ecosystem associated with Little Bear Creek. No mining is projected beneath Little Bear Creek. Although Little Bear Spring is located outside of the South Crandall Permit boundary and is not expected to be adversely impacted, because it is such an important source of water in the region, a water replacement agreement is in place to assure an uninterrupted supply of culinary water equivalent to historical flows from the spring. No adverse impacts to streams or springs are anticipated from subsidence.

FUTURE MINING

Underground mining may result in some diversions of intercepted ground water into drainages that are not topographically within (above) the area where the water was encountered. If it is demonstrated that mining has caused or will cause a diminution, contamination, or interruption of an appropriated water right or a material impact either within or outside of the permit area, the permittee will be required by the Division to address means of minimizing the impact and replacing any appropriated water rights. Evaluations of PHCs and the preparation of this CHIA do not indicate that there is any evidence that such impacts will result from the proposed mining in the East Mountain CIA, and as a consequence, there is no reason to require operators to propose alternatives for disposing of the displaced water or other possible actions as part of the PAP.

Increased rates of dewatering may in the future result in depletion of ground-water storage in some beds above the coal seams. Upon cessation of mining, ventilation losses and mine water discharge, if there has been any, will be discontinued. Ground-water conditions similar to those that existed before mining will probably be established as the mine workings flood.

Drainage from surface disturbance due to coal mining and reclamation operations will be managed through appropriate sediment controls. Waste rock storage areas will be adequately covered with topsoil and all disturbed areas will be stabilized and revegetated to prevent surface water contamination.

VIII. STATEMENT OF FINDINGS

The Utah Division of Oil, Gas and Mining finds that the proposed coal mining and reclamation operations in the Mill Fork Extension of the Deer Creek Mine and the South Crandall Lease area of the Crandall Canyon Mine have been designed to prevent material damage to the hydrologic balance outside the permit areas. No evidence of material damage from actual mining operations in the CIA has been found. No probability of material damage from existing and anticipated mining operations in the CIA has been found.

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ACRONYMS

AML	Abandoned Mine Lands
AVF	Alluvial Valley Floor
BLM	Bureau of Land Management
CIA	Cumulative Impact Area
CHIA	Cumulative Hydrologic Impact Area
CVSSD	Castle Valley Special Service District
DWR	Utah Division of Wildlife Resources
EA	Environmental Assessment
NEWUSSD	North Emery Water Users Special Service District
MRP	Mining and Reclamation Plan
MSHA	Mine Safety and Health Administration
PAP	Permit Application Package
PHC	Probable Hydrologic Consequences
PHDI	Palmer Hydrologic Drought Index
SMCRA	Surface Mining Control and Reclamation Act of 1977
UDOGM	Utah Division of Oil, Gas and Mining
UDWR	Utah Division of Water Resources
UDWQ	Utah Division of Water Quality
UPDES	Utah Pollution Discharge Elimination System
UP&L	Utah Power and Light
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey

PLATES

Plate 1 Wasatch Plateau Coal Field
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Plate 4 Surface Water Drainage Map
Plate 5 Potential Recharge Areas Above the Coal Resources
Plate 6 Water Monitoring Locations